Vol. XV. — No. 11. November 1933.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[385. (06. 112]

TWELFTH SESSION

Cairo, 19-30 January 1933.

GENERAL PROCEEDINGS

2nd Section : LOCOMOTIVES AND ROLLING STOCK.

INAUGURAL MEETING

20 January 1933 (morning).

PROVISIONAL CHAIRMAN : Dr. J. DORPMÜLLER,
MEMBER OF THE PERMANENT COMMISSION OF THE ASSOCIATION.

— The Meeting opens at 9 o'clock.

Dr. Dorpmüller (in German). — Gentlemen, I will open the inaugural meeting of the 2nd Section by welcoming the delegates who are to attend the discussions. I hope that your work will be crowned with success.

Gentlemen, it will be your task to solve some extremely important questions. The object of today's meeting is to determine the steps that could be taken in order to increase the mileage of locomotives between two heavy repairs. You know that considerable expenditure is involved in repairing our rolling stock. You also know that we have to fight against the serious competition of other methods of transport. For this double reason, we must labour to make the increase in the mileage run by locomotives between two successive repairs, a real one.

We then come to the second question on our agenda, concerning the most serious competition the steam locomotive has had to meet : Electrification of railways, which will be studied on the second day. You will have to decide on the best site for electric power generating stations, the choice of the type of current, etc. I suppose you have made yourselves familiar with the reports presented on this subject. It is extremely important that we should advance in the right direction as regards electrification. I ask you not to overlook the fact that, as far as electrification is concerned, we are now face to face with radical modifications. The new type of rectifier will perhaps lead to a complete revolution in the field of electrification. It is therefore necessary to be very prudent, so as not to invest large sums in installations which possibly will soon be completely out-of-date. But I have seen from the reports that this circumstance has been taken into account, and I am glad that the study of this question was confided to such competent persons.

The third question on our agenda is the construction of all-metal rolling stock. This measure makes possible a saving in the maintenance costs of vehicles and a decrease in the weight of the trains if welding is used instead of riveting and if better-quality steels are used. This new method of construction must not lead to an increase in the cost price of vehicles. On the other hand, the decrease in the load hauled will lead to water and fuel savings or electric current savings, and will enable the locomotives to haul longer trains or climb gradients without assistance.

I have now put before you in a general way the problems with which you have to deal. Again wishing that your work may be successful, I will now ask you to choose the President of the 2nd Section. For my part, after consulting various delegates and the officials of the present Congress, I suggest that you elect Mr. Student, Reichsbahndirektor (German National Railway Company). If there is no objection, I will now let Mr. Student take the chair as president of the 2nd Section. *(Applause.)*

— Mr. Student then took his place as President.

The President (in German). — I appreciate, Gentlemen, your choice, and it is my pleasant duty to thank you for the honour of presiding over a meeting of so many distinguished and eminent men. I hope that our common work will be fruitful.

Our task covers a wide field, and deals chiefly with questions of an economic nature. This remark applies not only to the increase of the mileage between heavy repairs, and to railway electrification, but also to all-metal construction of rolling stock. This is certainly a very heavy task to carry out and the time in which we have to do it is extremely short. Therefore, I must ask the delegates to make their remarks in as complete and at the same time as concise a manner as possible, so that everyone can have an opportunity of speaking, and that we may have as complete a summary as possible of everyone's opinions.

I propose that Mr. Chantrell, Principal Engineer of the Belgian National Railway Company, should be principal secretary. *(Applause.)*

I will ask Mr. Chantrell to make known the names of the vice-presidents, and I hope you will all agree with the choice made. *(Applause.)*

Mr. Chantrell, *principal secretary.* — The following Gentlemen are proposed as vice-presidents :

Messrs. O. Hendrich, ministerial councillor and chief of Department V/4, Ministry of Railways, Czechoslovakia.

L. Bochkoff, general manager, Bulgarian State Railways and Harbours, member of the Permanent Commission of the Association.

O. Tevfik Fazli, chief mechanical engineer, Turkish State Railways.

(Applause.)

— The Section, following the President's proposal, completed its Bureau and drew up a provisional agenda.

— The Meeting closed at 9.30.

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QUESTION IV :

Methods to be used to increase the mileage run by locomotives between two repairs including lifting.

Preliminary documents.

1st report (America, Great Britain, Dominions and Colonies, China and Japan), by Sir HENRY FOWLER. (See *Bulletin*, April 1932, p. 287, or separate issue No. 1.)

2nd report (Germany, Denmark, Finland, Norway, Spain, Netherlands, Portugal and their Colonies, Sweden and Switzerland), by Mr. E. STUDENT. (See *Bulletin*, June 1932, p. 983, or separate issue No. 15.)

3rd report (other countries), by Mr. R. KLATOVSKY. (See *Bulletin*, August 1932, p. 1539, or separate issue No. 23.)

Special Reporter : Sir HENRY FOWLER. (See *Bulletin*, January 1933, p. 43.)

DISCUSSION BY THE SECTION.

Meeting held on the 20 January 1933 (morning).

Mr. STUDENT, PRESIDENT OF THE 2nd SECTION, IN THE CHAIR.

— The Meeting is opened at 9.30 a.m.

The President (in German). — I will ask Sir HENRY FOWLER, the *Special Reporter*, to present his report.

Sir Henry Fowler, *Special Reporter*. — I feel very honoured that I have been asked to prepare the special report, which you have in your hands, and propose to say only a few words on certain paragraphs, on which I suggest that the discussion should take place. There are six points (on page 46) of the special report.

There is one marked difference in the reports : our Czechoslovakian friend regards the main cause for the repair of locomotives as being tyre wear, whereas you, Mr. President, and myself think that it is the boiler.

I do not, at this time, propose to speak at length on the subject, as I say, but to be as brief as possible. I have endeavoured, in six paragraphs, to summarize the three individual reports and suggest that they should form the basis of our discussion.

The President (in German). — Sir Henry Fowler's resumé brings out the six principal practical points which are the determining factors in increasing the mileage or the service capacity of a locomotive. I will therefore ask you to vote on Summary 1 as follows :

One of the chief reasons for locomotives requiring heavy repairs is the attention which has to be given periodically to the boiler. It is, therefore, obvious that boiler design is of primary importance, and arrangements should be made for it to receive suitable water, and for it to be washed out properly.

In many countries, the boiler is only generally repaired after a considerable number of years. The time laid down is, for example, 4 years in Denmark, 5 to 6 years in Bulgaria, and 6 years in Germany. In all cases, this interval between two consecutive boiler repairs is very long, and it is impossible for the locomotive to be in service such a long time. Consequently this period is broken up, according to whether it is a question of express locomotives, etc., by two or three heavy repairs. A certain number of administrations have said in this connection : The time for these general heavy repairs is determined by the general condition of the locomotive. But then the locomotives are in such bad condition that they have to be completely repaired.

In order to make the time between two heavy repairs as long as possible — because the expenditure involved is considerable — the question has been asked how the interval can be made the longest possible. The reply given is this : Periodical examinations and intermediate repairs.

In Germany, in the case of express locomotives, we have obtained a mileage of as much as 217 500 miles between two heavy repairs, which coresponds to two years' service. Therefore, if in Germany the boiler undergoes heavy repairs every 6 years, it would be after three times this mileage, which is evidently impossible. It is necessary, in consequence, to make heavy repairs to the locomotive between the heavy repairs to the boiler.

I would therefore like to add, to the text of summary 1 that, in addition, the general condition of a locomotive is also a determining factor for heavy repairs.

I would also like to hear your opinion on the method of construction of the boilers. It is obvious that the method of construction of the boilers can have an influence on the question of maintenance. I would like to know if any member has anything new to say on this point.

Mr. Munck, Danish State Railways. — It has been stated in one of the reports that the interval between two boiler inspections in Denmark, is four years. Only a couple of years ago this interval was 3 years, alternate « inside » and « outside » inspection, when the boiler lining was taken off and the boiler put under pressure. I found that at the boiler inspection, i.e. the outside inspection, there was such a lot of work to do to the boiler, that it nearly amounted to the same as for an inside inspection. I therefore gave up the outside inspection and arranged for inside inspection only, with a longer interval, namely four years. I do not think it is possible for Denmark to get longer intervals because, according to law, stationary boilers have to be inspected every four years.

As to the mileage run between two repairs, especially intermediate repairs between the big boiler repairs, I do not think any definite time or mileage can be laid down, because the condition of the track is an essential factor as regards

the life of the various parts of the locomotive. We have identical locomotives running on light track and on heavy track on the Danish State Railways. Whereas the light track has rails of 32 kgr. per m. (64.5 lb. per yard) the heavy track has 42 kgr. per m. (84.7 lb. per yard) rails. On the light rails we only obtain a mileage of 35 to 40 000 km. (21 750 to 24 850 miles) before the tyres are to be re-turned, whereas on the heavy rail we are getting more than 200 000 km. (124 000 miles) before the tyres are reconditioned. For the intermediate repairs we replace all such parts which cannot be expected to stand the wear until the first boiler inspection, the heavy repairs always being combined with the boiler repairs.

I think that money spent on improving the track, is money well spent.

Mr. Chalk (North Western Railway, India). — I agree with the speaker on a very important point. We are told that different mileages are obtained in different countries. Mr. Munck talked about the mileage of locomotives run on light rails and heavy rails, but my experience has been that before we can lay down any particular rule, we must come to some form of conclusion. Are we dealing with countries or districts, with the same class of material? We find in India, on certain railways, boilers represent comparatively a small problem.

We, on the North Western Railway of India, have the greatest problem in gradients and water, and I think it would be well if we could come to some form of agreement about the mileage and cost of repairs, and be able to classify the districts and countries on the same basis.

Mr. Spurgeon (North Western Railway, India). — On the North Western Railway, of India, we try to keep our engines out to obtain the most mileage possible between heavy repairs. For budgeting purposes we estimate for an average of 70 000 miles between heavy repairs, but we may obtain more or less than this, which chiefly depends upon the boiler, and on the water used, and the district the engine is working in. Some boilers may only do a very small mileage, but then it again depends on the age of the boiler. A new boiler may run 150 000 miles before a heavy repair. At an age of about 10 years, it may only do 50 000 miles.

It is doubtful if we should do our intermediate repairs in the running sheds or in the main workshops. The sheds are very far away, and it would mean a lead of about 800 miles to the shops, which would mean a waste of time to bring the engine into the main shops.

We would like to do intermediate repairs in the main shops, where the organization is available. In order to obtain a heavy mileage between shoppings, there is a complete imprest of duplicates in sheds to facilitate intermediate repairs.

We have seven boiler inspectors, who inspect boilers after the specified mileages, dependent on the age of the boiler. If a boiler is fit to run beyond a specified mileage, a certificate is given for a further definite mileage or time before being brought into the shops.

On some districts which are very sandy, we obtain a very small mileage out of the tyres. These are turned up in the sheds, and if they require new tyres, the wheels are sent to the shops.

By this means, and the careful washing out of boilers, we aim at obtaining the greatest possible mileage between heavy repairs in work shops.

Mr. Bals, Rumanian Railways (in French). — The President has asked if Sir Henry Fowler's proposal, saying that

the state of the boiler is the determining factor in deciding locomotive repairs, should be maintained in summary 1.

According to the wording, it is a question of the measures to be taken to increase the mileage between two repairs including lifting.

Now there is lifting and lifting. The locomotive can be lifted every time the wheels have to be taken off to turn up the tyres, or to put new pairs of wheels under the locomotive. But there is also the case in which this lifting is accompanied by lifting of the boiler out of the frame : this is the case with heavy repairs.

It is this last case which involves heavy expenditure and which is a very important economic factor.

The question set seems to deal more particularly with the increase of the mileage between two repairs in which heavy repairs to the boiler are carried out, seeing that these are the most expensive, and that investigations made to increase the time in service of the locomotive should tend in this direction.

It is true that each time a locomotive is lifted to change the wheels, certain repairs are made to the locomotive. But as a rule, these repairs are less costly than those involved when the boiler is so worn that repairs requiring the lifting of the boiler itself are necessary.

I consider therefore that the President's question could be interpreted as relating to heavy repairs made necessary both by the state of the boiler and of the locomotive.

Sir Henry Fowler. — At the beginning of my report, page 288 of the English edition, I have made this definite statement regarding this point :

« It will be appreciated that the repairs referred to in question IV, are those which necessitate the locomotive being dealt with in the main shops of the railway. This seems to have been generally understood from the replies received. »

Mr. Duchatel, Est Railway, France (in French). — I think there is some confusion about the meaning to be given to the title of the question.

Paragraph 1 of the summaries of the special reporter reads :

« One of the chief reasons for locomotives requiring heavy repairs is the attention which has to be given periodically to the boiler. »

In reality, on our railway, we call in practice « heavy repairs » those made necessary to put into proper working order important parts of the boiler, the firebox in particular.

These heavy repairs are separated by very long intervals. We have many locomotives which only undergo such repairs at intervals of 8, 10 and even 12 years.

It is obvious that an engine cannot remain in service for 12 years without undergoing any heavy repairs on the pretence that its boiler is still good.

Between the heavy repairs which make it necessary for the locomotive to return to the shops for heavy boiler repairs, we have the usual periodical repairs which are called « levage » (lifting). These repairs are made necessary by the general condition of the parts of the locomotive other than the boiler, by the general condition of the running gear, the cylinders, the valve gear, etc.

I think that some of the replies suppose that the heavy repairs are what we call « lifting », whereas other replies are only considering the operations which we call « heavy repairs ». As a result, it may be difficult to come to any agreement if we are not agreed upon the terminology.

I will leave it to the Special Reporter to do this.

Mr. Shove, East Indian Railway. — In the final summary of Sir Henry Fowler's report it states, that the chief reason for undertaking heavy repairs is the need of repairs to the boiler.

The most vital part of a locomotive boiler is the firebox, hence, to lengthen the period during which the firebox can be kept in service between heavy repairs will automatically tend to do the same for the whole engine.

On page 299 of the Report, it states that on the Norfolk and Western Railroad, welding of various parts has practically eliminated trouble in the operation of boilers.

While in the United States, in 1927, I was shown a very large firebox of welded steel plates with three Nicholson syphons. In the manufacture of this firebox not a single rivet was used, and all the joints were butt-welded, with the result that there was a minimum of thickness of metal throughout the firebox exposed to the action of the fire.

Such fireboxes should compare favourably in service with those made with riveted lap joints, with the consequentlly increased thickness of metal at the joints.

I think it would be useful if our American friends could give us some information as to whether welded steel fireboxes are found to be reliable in service, and also some details of the repairs found necessary in shops, with cost of same, and the life of such fireboxes compared with those riveted.

Sir Henry Fowler. — There is, unfortunately, only one delegate from the United States Railways, and he is a traffic man.

The President (in German). — Perhaps I can give you some information on this point. The German State Railway Company has begun to make use of welding on locomotives, not only in the case of such simple parts as the fireboxes, etc., but also for entire boilers, the fireboxes and the longitudinal joints of the barrels. For trial purposes, all the joints of the boiler, except the tube plate of the smoke box, and the side seams of the throat sheet (sheet connecting the firebox and the barrel), are to be welded. The same will be done in the case of the copper fireboxes and the steel wrapper plate. I have a complete list of the parts in question, which the delegates can see if they like.

Mr. Spurgeon. — Coming back to what is a heavy repair, as it has been discussed by many delegates : « what is the heavy repair? »; this could be fixed by giving so many points to each operation which is done on the engine and boiler and, if the number of points exceeds 100, it would be termed a « heavy repair ».

The only method of properly inspecting boilers is, by taking out all the tubes and thoroughly cleaning all plates and bringing the boiler and engine into shops. This inspection cannot be carried out satisfactorily in running sheds.

Boilers are also inspected every quarter by running shed boiler foremen.

The mileage between heavy repairs is, therefore, fixed on the boiler mileage, dependent on the age of the boiler.

Sir Henry Fowler. — This question was discussed in my report under « periodical examinations of the boiler ». These examinations have been laid down by law in certain countries.

Mr. Tevfik Fazli, Turkish State Railways (in German). — In Turkey, where

the feed water is very bad, the boiler has to be repaired more frequently than elsewhere. Two inside examinations and one repair are made after a mileage of 120 000 to 150 000 km. (75 000 to 93 000 miles). As the traffic is not very heavy in Turkey, the mileage is naturally lower than in other countries. However, we do not make a general inside examination after 120 000 to 150 000 km., but only, as a heavy repair, after about 250 000 to 300 000 km. (155 000 to 186 000 miles). In spite of the frequent intermediate repairs, the state of the boiler is with us the factor which determines the general repair.

The President (in German). — May I express the opinion that as regards the 1st paragraph of Sir Henry Fowler's summaries, we agree to say : « The heavy repair of a locomotive includes all parts of the machine without it being necessary to add the repairs known as « interior » or « exterior examination » of the boiler. It goes without saying that all defects in the boiler, discovered during the heavy repair, are repaired at the same time. Heavy repairs coincide in every case with the heavy repair to the boiler, but occur more frequently than the latter. We have seen that heavy repairs to the boiler take place at intervals of 4, 6, 8, 10, and even 12 years on the French railways. During this period, it is obviously necessary to carry out many general repairs of the locomotive, but heavy boiler repairs will always be accompanied by a general overhaul of the locomotive. This, I think, is what we have understood during this discussion.

As regards Sir Henry Fowler's remark about the importance of the method of construction of the boiler, everyone is of the same opinion. The locomotive boiler is a very delicate part, and frequent washings are therefore necessary. Consequently, as Sir Henry Fowler explains, it is necessary to make provision for washing out the boilers thoroughly. The arrangement of the washing-out holes is of considerable importance in the maintenance of the boiler. We have seen in the reports that many administrations are satisfied to wash out once a month. The German State Railway Company prescribes at least two wash-out's a month, but we sometimes wash out three and even four times. At any rate, two wash-out's a month is the minimum required to make sure that as little scale as possible is deposited. We can therefore consider Summary 1 as adopted. We must suppose, on the other hand that, as Sir Henry Fowler has said in the *2nd paragraph of his summaries* :

> Regular and systematic examinations tend to the discovery of defects, and the renewal of worn parts, and so prevent casualties, and loss of mileage.

These periodical examinations of certain parts of the locomotive are more or less usual on every railway. I presume that you approve of the text and tenor of this second paragraph. *(This was agreed.)*

Mr. Gresley, London & North Eastern Railway. — I have listened with great interest to the discussion which has taken place in regard to this paper. In respect to the summary of the recommendations, it seems to me that this is really only a recital of elementary essentials of proper maintenance of locomotives, and I must confess that I am disappointed that I have been unable to see how the mileage between each repair is going to be materially increased.

Concerning summary No. 1, with regard to the boiler, I think we all agree that the boiler is the governing factor, and it is very difficult to make standard recom-

mendations when you have not got standard conditions. The conditions in all countries vary so much.

As Mr. Duchatel mentionel just now, on the Est Railway, in France, a locomotive will run for 10 to 12 years before heavy repairs are required to the boiler. Mr. Tevfik Fazli says the water is very bad in Turkey. On my own railway, in Scotland, the water is very good, and boilers can run a long mileage without requiring repair.

I have known engines run approximately 100 000 miles and no repairs required to the boiler. On the other hand, in some parts of England, boilers have to be condemned and replaced by new boilers in five or six years. In these districts the mileage between heavy repairs is reduced to only about 25 000 to 30 000 miles. Consequently, those engines have to come in for repair before the running parts require that the engine should be lifted. Therefore, in considering the mileage which can be run by engines between heavy repairs, the quality of the water is the governing factor.

The President (in German). — The Section being agreed about summaries 1 and 2, we can go on to examine the following summaries.

Summary 3 is worded as follows :

Tyres usually require to be re-turned between heavy repairs, and, therefore, every attention should be given to providing material which will give as little wear as possible. The study of the relation of the wear of tyres and rails merits more attention than has so far been given to it.

I suggest that it would be better if we first of all consider *Summary 4*, worded as follows :

An intermediate repair, where tyres, bearings, etc., receive attention, can be quickly carried out if systematically performed, and materially increases the mileage between heavy repairs.

We will obviously have different ideas about intermediate locomotive repairs when we consider that the cost of general repairs is very high. 25 000 Reichsmarks must always be allowed for such repairs, i. e. a very large sum of money which we only wish to spend at long intervals. The reports made by Sir Henry Fowler and myself agree with the reports of many administrations in saying that intermediate repairs should take place between heavy repairs, the former only covering parts prematurely worn during service, which in many cases also means reconditioning the tyres and bearings, as well as the pistons and valves. These repairs can be made at relatively small cost. A repair of this kind costs the German State Railway Company about 4 000 to 10 000 Reichsmarks. In this way, the heavy repairs are only necessary at longer intervals and this is the end we should strive for.

If the expenditure on repairs is expressed in terms of a unit of mileage run, for example 1 000 locomotive-kilometres, we find in Germany that the maintenance costs per 1 000 locomotive-kilometres decrease when the heavy repairs can be deferred, and when all defects can be made good by intermediate repairs. In this way we have obtained considerable savings in maintenance, particularly from the point of view of the mileage run, i. e. the distance run between two heavy repairs increases faster than the cost of maintenance.

Mr. Bals (in French). — I think it would be well to stress in this connection the standardisation of parts liable to wear, as this accelerates repairs.

The President (in German). — I do not think that it is possible to carry out such standardisation, nor that it is opportune to undertake it.

As far as Germany is concerned, in particular, intermediate repairs are usually concerned with the locomotive mechanism. But it is very possible that intermediate repairs may also be valuable in the case of the firebox. The object of the intermediate repairs carried out in a main shop is to repair only those parts which are so worn in service or damaged that it is absolutely necessary to repair them if the locomotive is to continue to run.

Sir Henry Fowler. — I would like to have permission to read an extract from a memorandum I have received as a member of the American Railroad Association. It is stated that : « Service tests which have been under observation since 1926 show very little, if any, difference in service life, which can be attributed to the taper or elimination of the secondary taper of the tyre face. »

Mr. Forte, Italian State Railways (in French). — The three reports on Question IV are more or less agreed in affirming that, in order to reduce the wear of the tyres, these should be made of a harder steel than that used for the rails; this is confirmed by the specifications of the majority of administrations who replied to the questionnaire.

I quite agree with those who are of the opinion that the question of tyre wear on the tread and the flange should be more closely gone into, both from the point of view of the profile of the tyre and the rail, and from the point of view of the quality of the metal used.

As regards the quality of the metal, I think it useful to call your attention to the fact that at the « Experimental Station of the Italian State Railways » investigations are being made to determine, by means of static wear tests, the best characteristics for increasing the resistance of the rails and tyres.

It must also not be forgotten that the tyre and rail do not retain their original hardness on their running surfaces, but that this hardness increases progressively as a result of the rolling of the one on the other. But whereas the rail remains constantly in service and increases in hardness until it reaches, as has been ascertained, 130 kgr. per mm² (82.5 Engl. tons per sq. inch.), the tyre has to be returned and in this way the hardened surface is removed.

It has been ascertained that, as a rule, the running surface of the tyre is less hard than that of the rail. The original ratio between the hardness of the tyre and that of the rail changes in value inversely, and the tyre has no longer a greater resistance on its running surface than that of the rail, as was at first the case.

This modification leads to two results : in the first place it has been observed that tyres originally of different tensile strength show more or less the same wear.

This is due to the fact that in a very short time the running surface of the semi-hard tyres reaches more or less the same degree of hardness as that reached by the hard tyres in service.

In the second place, there has been deduced from this that, in order to guarantee at all times a comparatively higher resistance of the tyre than of the rail, it is necessary to use tyres which have, when new, a tensile strength of at least 100 kgr. per mm² (63.5 Engl. tons per sq. inch) which after running becomes

120 to 130 kgr. (76.2-82.5 Engl. tons per sq. inch). These tyres ought, however, to have a resiliency of at least 5, so as to avoid the danger of being too brittle.

These two conditions can be satisfied by using special steels, or by heat-treated ordinary carbon steels.

Naturally we are still in the experimental stage, but Italy, following the example of Great Britain and America, proposes to continue investigating this problem, and in addition to start making practical trials with this sort of tyre.

By using harder and tougher tyres than those used up to the present, we hope in practice to be able to reduce wear, and consequently to obtain a still further increase in the mileage between two returnings.

In this way it should also be possible to reduce flange wear, which moreover depends upon other phenonema which I cannot deal with here.

I think that this question is of particular interest from the point of view of the increase of speeds and loads, which everyone is aiming at.

Mr. Wood, Sudan Railways. — Referring to Sir Henry Fowler's remarks on the memorandum of the American Railroad Association, I notice in his original report (page 293), plain tyres are shown, i.e., where the tyres are flangeless the tread is turned cylindrical instead of taper. I consider this to be a remarkable practice when one remembers that this cylindrical tyre is running on a rail inclined inwards to suit a taper tyre; the result is that the tyre bears only on the edge of the rail. I notice this particular arrangement on other railways where tyres are without flanges, and I shall be very pleased indeed to know if there is any reason for this. From my experience on the railway I represent, I have found that the cylindrical tyres wear far more than any others, and determine when the engine must go to shops for tyre turning. It seems to me that in the case of flangeless tyres, as they usually are driving tyres and have a great deal of work to do, they should be given every assistance by turning them to the same taper as the inclination of the rail so that the tread is in contact with the whole rail table instead of riding on one corner.

Sir Henry Fowler. — The information which I received from the Sudan Railways did not give any contour showing a flangeless tyre.

Mr. Bals (in French). — I should like to know if the trials now being made at the Experimental Station of the Italian State Railways also deal with the behaviour of tyres at low temperatures, i. e. during very cold weather.

Mr. Forte (in French). — We do not have very low temperatures in Italy, but according to tests made elsewhere, it appears that at low temperatures different results are obtained according to the qualities of the metal.

There are some metals, alloys in particular, the strength of which is good at low temperatures.

We have decided to make practical tests, and I think that later on I will be able to give my colleagues full information.

Sir Henry Fowler. — May I refer you to a report of Dr. Küber, of Düsseldorf, in which extensive details are given on tests of this description?

The President (in German) — Sometimes we also have low temperatures in Germany. They are not so low, it is true as in Rumania, but the thermometer can

fall as low as —29 and —30° C. (—20.2 and —22° F.). We have not had any occasion to complain from damage to tyres. I think that when tyres crack as a result of very cold weather, investigations have shown that the shrinkage allowance, when made too great, exceeds the elastic limit, and blows at the rail joints then cause trouble. The shrinkage allowance is therefore a factor to be considered in this question.

Mr. Shove. — On page 301 of Sir Henry Fowler's report he mentions that there is a tendency to use grease for lubrication of the machinery of locomotives, in countries where the temperature is fairly high. He adds that no remarks had been made as to its efficiency as a lubricant.

Grease lubrication is practically universal on American and Canadian railways where the climate varies from semi-tropical to almost arctic, and in the course of my tour in these two countries, in 1927, I was assured by all concerned that hot bearings were far less frequent with grease and that higher mileages per month were obtainable than with oil lubrication.

With regard to the efficiency of grease as a lubricant, I would suggest that the functions of a lubricant are two, namely : to reduce to a minimum both the wear and the resistance of the moving parts. Our experience on the East Indian Railway is that wear is decidedly less with grease than with oil, the reason for this, in my opinion, being that the film of lubricant is broken down less frequently with grease than with oil when starting and stopping or working heavily. It is obvious that the resistance of bearings with the heavier lubricant must be more than with oil and this is proved by the fact that their normal running temperature is higher, but the additional resistance is not found to result in a higher coal consumption and so would appear to be negligeable as far as the cost of operation is concerned.

I venture to make these remarks as it appears to me to be of vital importance to ensure that the lubrication of all wearing parts of the locomotive is as efficient and automatic as possible, so as to reduce wear to an absolute minimum and thus automatically enable the mileage between shop repairs to be increased. Our experience has shown that the heavier and more lasting lubricant, i. e., grease, is more effective in this respect than oil.

Mr. Spurgeon. — On the North Western Railway, India, we have used grease lubrication on our large express engines and find there is considerable wear on journals and crank pins, but this greatly depends on the quality of the grease used, which is a very important factor.

Oil lubrication has a lower co-efficient of friction so that it is anticipated there would be more wear on journals, etc., with grease lubrication than with the use of a good quality of oil.

The use of floating bushes on crankpin bearings has considerably reduced wear with grease lubrication.

Mr. Duchatel (in French). — I should like to say a few words about summaries 5 and 6; summary 5 says that there is a tendency to increase the daily mileage of locomotives and it has been concluded from this that the total mileage between two heavy repairs could also be increased.

I agree that there is a tendency to increase the daily mileage of locomotives, but as to the deduction therefrom as regards an increase in the mileage between heavy repairs, we have not found this conclusion at all; on the contrary we observed the opposite. The reason is

probably due to the fact that our locomotives are always working nearly at full power.

This leads me to speak about summary 6. It is quite exact to say that by working the locomotives less, they can be made to run a greater mileage between repairs. I even think that the maximum mileage would be obtained if the locomotive was always running light. But the locomotive is only one of the tools we use for transport purposes, and the final object of the railway is to carry out transport as economically as possible.

In order to do this, it is necessary to work the locomotive as closely as possible to its upper limit of power. The consequence is that more frequent and more expensive repairs are needed, but nonetheless on the whole the transport costs are considerably reduced.

The President (in German). — Actually we are dealing with paragraph 3. The question of the tyres must no doubt be solved in the sense that we can agree with the general statement of Sir Henry Fowler. We have to find a relationship between the rail and the tyre, thanks to which both tyre and rail will wear as little as possible. The question of the profile is examined in the reports, and it is moreover a much disputed question. Investigations into the contour of the tyre and the rail have not yet been made on a sufficiently wide scale.

We have also touched upon the question of knowing whether the tyre should be given one or two inclinations. Nor can this question be cleared up today. The number of results of experiments and trials available is not sufficient. Finally, as far as the design and materials are concerned, here again it is not possible to lay down general rules, not only in the case of the tyre and the rail, but also as regards the axleboxes and bearings, their white metal linings, and their lubrication. Those of us who live in a temperate climate also use a different oil in summer and winter, but only for the sake of convenience and economy. In hot countries, conditions are quite different, and it may be desirable in such cases to use grease as a lubricant. Our only concern is to ensure as even as possible a distribution of the oil, particularly on very heavily loaded surfaces. To obtain this result, we have adpoted the felt strips (figure 4 of my report) of such a form that the oil is thrown back towards the middle of the driving and coupling rod crank pins. This use of felt strips has given us very good results, particularly in the case of the crosshead pins which are always under load at a known point, so that very thorough lubrication is necessary.

To sum up, we could keep summaries 3 and 4 as worded by the Special Reporter. *(Agreed.)*

I would now like to say a little on the question of service. Sir Henry Fowler speaks about this as follows in paragraph 5 of his summaries :

> There has been a tendency in recent years to obtain a greater mileage per day from locomotives by various means; this in an advantage in itself, and also tends to increase the total mileage between heavy repairs.

On going through the replies of the administrations represented by Sir Henry Fowler and myself, it will be seen that there is a marked tendency for the locomotives to be worked by more than one set of men. In America this system is carried still further, so that on long runs the locomotive is worked by as many as five different sets. In my opinion this is equivalent to pooling the engines. In any case the idea is to get as much work out of the locomotive as possible, first of

all by making it run long distances, and finally by working it by different sets of men, so that the work of the locomotive is made independent of the working conditions of the staff. With a single set of men, the locomotive's work is hampered by the legal requirements as regards the work of the staff. However in order not to cut out the question of using a single or multiple set of men, Sir Henry Fowler says that the daily mileage of the locomotive should be as high as possible, the result being a high mileage between two repairs.

The choice of the methods to be used to obtain this high daily mileage is left by Sir Henry Fowler to the different administrations. Decisions of this kind can never be strictly laid down. In any case, the high price of a locomotive justifies the desire to make good as far as possible the high capital charge by an intensive use of the locomotive.

Mr. Bals (in French). — We are evidently agreed on the first point of summary 5, relating to the best utilisation of locomotives, by increasing their daily mileage.

I would like, however, to hear more precise opinions on the end of this summary which says that the increase of the daily mileage contributes to increasing the total mileage between two heavy repairs.

Obviously the boiler suffers, as Sir Henry Fowler and the reporters have pointed out, from changes in temperature, i.e. from alternatively being put under pressure and cooled down. From this point of view maintaining the locomotive under pressure as long as possible helps to avoid damage, cracks, etc.

On the other hand, it may be asked if the fact that the firebox is continually submitted to the action of fire over considerable periods would not make heavy repairs necessary all the sooner; the ends of the tubes, etc., suffer in the case of an engine with a high daily mileage.

I would therefore like to know — and I think it is a point that should be elucidated — if, in reality, longer daily mileages contribute to increase the total mileage of locomotives unless special precautions are taken, such as for example the use of special metals, special methods of construction, etc.

Sir Henry Fowler. — Might I say one word on this question? Personally I feel it to be a great advantage towards increasing the daily mileage. For instance, keeping the boiler hot, I think, causes it to wear a good deal less per mile run.

Mr. Bals. — In spite of the direct action of the fire?

Sir Henry Fowler. — Certainly.

The President (in German). — We will therefore retain the wording of this summary. We will now take summary 6 :

Where it is possible, and the permanent way and loading gauge allow, it is an advantage to employ locomotives which are ordinarily worked well below their maximum capacity. The increased capital cost, however, must be borne in mind.

We must know in particular if the administrations who work their locomotives to the limit of their power approve of the proposed text.

With us, in Germany, and according to Sir Henry Fowler also in other countries, it is not recommended to work in actual practice the locomotives to their maximum power, for the following reasons : 1. the efficiency of the boiler and the engine is necessarily lower, and consequently the coal consumption increases;

2. the locomotive which is always worked at full power also shows, as far as its utilisation is concerned, an unfavorable fatigue in all its parts.

When rail motor cars were introduced in Germany, the intensive service required from them obliged us always to work these vehicles at their utmost limit. The consequence was the very rapid wear of the different parts, and an excessive consumption of fuel. At present, we endeavour to work these motor cars within the same limits as the steam locomotives. In the case of the latter, the proportion of the power developed can be about 75 % of the maximum and experience has shown that under these conditions the working of the locomotive is the best from the point of view of coal consumption.

If the locomotives have rarely to be repaired, because they are not required to work too hard, they can give a better mileage than when, because the engines are working to utmost power, the heavy repairs are closer together. The maintenance cost are moderate if the locomotives work within given limits, below their maximum power. *(Marks of approval.)*

As no one raises any objection to summary 6, we will consider it as adopted, subject to some modifications of form to be made by the Secretariat.

— The Meeting ended at 1.30 p.m.

DISCUSSION AT THE PLENARY MEETING.

held on the 24 January 1933 (morning).

H. E. Ibrahim FAHMY KERIM Pacha in the Chair.

General Secretaries : Messrs. P. GHILAIN, Youssef RISGALLAH Bey, Dr. I. G. LEVI and FOUAD HASSIB Bey.

Assistant General Secretaries : Sir Henry FOWLER and Mr. P. WOLF.

Mr. Ghilain, *General Secretary*. — We will now examine the summaries of Question IV, which were published in the *Daily Journal of the Session* No. 2, of the 21 January.

— *The Summaries were read.*

Mr. Ghilain. — As regards summary 4, I received a request for its modification : it was proposed that the words « an intermediate repair » should be replaced by « intermediate repairs ». *(Approved.)*

The President. — As no objections have been made, we will consider the summaries of Question IV as adopted, with the modification made to summary 4.

Summaries.

« 1. One of the chief reasons for locomotives requiring heavy repairs is the attention which has to be given periodically to the boiler. It is, therefore, obvious that boiler design is of primary importance, and arrangements should be made for it to receive suitable water, and for it to be washed out properly.

« 2. Regular and systematic examinations tend to the discovery of defects, and the renewal of worn parts, and so prevent casualties and loss of mileage.

« 3. Tyres usually require to be returned between heavy repairs, and, therefore, every attention should be given to providing material which will give as little wear as possible. The study of the relation of the wear of tyres and rails merits more attention than has so far been given to it.

« 4. Intermediate repairs, where tyres, bearings, etc., receive attention, can be quickly carried out if systematically performed, and materially increase the mileage between heavy repairs.

« 5. There has been a tendency in recent years to obtain a greater mileage per day from locomotives by various means; this is an advantage in itself, and also tends to increase the total mileage between heavy repairs.

« 6. Where it is possible, and the permanent way and loading gauge allow, it is an advantage to employ locomotives which are ordinarily worked well below their maximum capacity. The increased capital cost, however, must be borne in mind. »

[621 .33]

QUESTION V :

Electrification of railways from an economic point of view. Selection of sites for generating stations. Choice of the kind of current. Safety precautions, etc.

Preliminary documents.

1st report (America, Great Britain, Dominions and Colonies, China and Japan), by Mr. S. WITHINGTON. (See *Bulletin*, April 1932, p. 379, or separate issue No. 3.)

2nd report (Belgium, Spain, France, Italy, Netherlands, Portugal and their Colonies, Denmark, Finland, Luxemburg, Norway and Sweden), by Messrs. JAPIOT and LEBOUCHER. (See *Bulletin*, September 1932, p. 1717, or separate issue No. 26.)

3rd report (other countries), by Messrs. E. HUBER-STOCKAR and H. ECKERT. (See *Bulletin*, June 1932, p. 857, or separate issue No. 12.)

Special Reporter : Mr. JAPIOT. (See *Bulletin*, January 1933, p. 47.)

DISCUSSION BY THE SECTION.

Meeting held on the 21 January 1933 (morning).

Mr. E. STUDENT, PRESIDENT OF THE 2nd SECTION, IN THE CHAIR.

— The Meeting is opened at 9.30.

The President (in German). — Gentlemen, I regret to state that the Special Reporter, Mr. JAPIOT, is unable to present his report to us in person. Mr. LEBOUCHER has been good enough to take his place and I therefore request him to come up on the platform.

Mr. Leboucher, *Reporter* (in French). Gentlemen, allow me to give you a brief summary of Mr. Japiot's special report.

The *first part* deals with electrification from the economic point of view.

Save in exceptional cases, electrification of a line already worked by steam makes necessary a large investment of new capital, and consequently leads to a heavy increase in the capital charges.

On the other hand, it may give appreciable savings on the operating costs.

Electrification can, therefore, be considered as economical when the supplementary capital charges are completely covered by savings in the operating costs.

Unfortunately it is very difficult to get out an exact balance-sheet in advance, but it may be stated that the capital charges are nearly always the most important factor in the cost of electrification.

According to one of the reporters, these charges can be as much as 65 % of the whole cost of electric traction, while the operating costs only represent 35 % of the whole.

In the case of steam traction, the operating costs are of the order of 90 % of the whole, against only 10 % for the capital charges.

The figures show the importance that must be attached to the rate of interest at the time the electrification is undertaken, and how necessary it is, when carrying out such work, to take advantage of periods when money can be obtained at a low rate of interest.

It will also be seen how important it is to calculate, for each item of expenditure, not only the actual rate of interest and the amortisation corresponding to the actual conditions for paying it off, but also an industrial amortisation which makes it possible to make provision for replacing certain parts of the installations or stock at an earlier date, on account of wear or simply obsoleteness.

The operating costs can be divided up as follows :

1. Supplies to the locomotives and rail motor coaches whether in electric energy or in fuel and water.
2. Driving the locomotives and rail motor cars.
3. Maintenance and lubrication of locomotives and rail motor cars.
4. Heating passenger trains in Winter.
5. Miscellaneous expenditure in the depots.
6. Permanent way maintenance.
7. Train staff.

In order to compare the costs of locomotive fuel or power, on the one hand the price of coal on the tender and, on the other, the price of current at the locomotive have to be computed, taking into account the whole cost of production of the current, its transportation and transformation.

The cost price of electric energy varies a great deal. Current can be either produced or bought.

A large railway system using current for more than 4 000 hours often finds it interesting to have its own power stations and to connect these up with the neighbouring stations which can, if need be, assure an additional supply.

In order to reduce the consumption of power, endeavours are being made to improve the overall efficiency of the transformation, in particular by making the substations automatic.

The cost of driving electric locomotives is always appreciably lower than that of steam locomotives on account of the reduction in the staff required, the greater power of the electric locomotives, the use of several sets of men, and the possibility of using only a single man on the engine.

Maintenance and lubrication of electric locomotives rarely represents more than 60 % of the cost of maintenance and lubrication of steam locomotives.

The heating of electric trains is an important item that must be taken into account, whether this is done by means of steam, by a boiler on the locomotive, or by a special van, or by means of electric radiators fed by the traction current.

The various expenditures at the depots, the maintenance of the permanent way and buildings, the cost of the train staff, etc., are always appreciably decreased by electrification.

Finally, indirect advantages often lessen the operating costs to a considerable extent.

Second part : The choice of the site of the power stations for supplying the electrified railway system with current is guided by the same considerations as in the case of a station feeding ordinary distribution systems.

Third part : Choice of the type of current.

At the present time there are three kinds of current :

three-phase current;
single-phase current;
direct current.

Three-phase current, used in Italy with the greatest success, does not seem likely to be used for further applications except for extensions of existing installations.

Single-phase current, used at low pressure on the motors, has developed very rapidly owing to the simple construction of low-pressure motors, the simplicity of the equipment, and the possibility of having a high tension on the trolley, which makes it possible to transport high powers over very light lines.

Finally direct current, which was the first used, but at low voltage, has only developed since the progress in technique has made it possible to build 1 500 and 3 000-volt motors.

Both direct and single-phase currents make it possible to obtain at the present time all the technical results required in the most difficult cases, and the way the work is carried out is of greater importance than the choice of the system.

The choice of this system is therefore at the present time a purely economic question, i.e. the technical modalities proper to each system only play a part in the comparision by their effect on the capital charges and operating costs.

Fourth part : The safety measures taken to protect the staff against accidents are very similar to those on ordinary electric distribution systems. However certain complementary measures are taken, in particular in the case of the contact lines and the locomotives.

Accidents are very rare, and nearly all those that occur are due to a mistake or the carelessness of the victim.

I now have to read you the summaries proposed by Mr. Japiot.

The President (in German). — The summaries put forward on pages 70 to 72 of the January 1933 *Bulletin* are, as you will have appreciated, so well conceived from the point of view of both form and matter, that we can hardly have any modifications to them to consider. In discussing the different points, will you please note that the question of the economic value of electrification is dealt with in paragraphs I-1 to I-6 and includes, in addition, the drawing up of the balance-sheet, capital charges, etc., and the economic questions properly speaking. Therefore I will ask you to examine the economic question first of all, as it is one of the more interesting.

The Reporter will now read the six paragraphs relating to the first part of the question.

Mr. Leboucher :

I-1. — Electrification is in general characterised from the economic point of view by a heavy increase of the capital charges, by savings, frequently considerable, on the operating costs and finally by indirect advantages which may in certain cases play the predominant part; the balance sheet of the electrification should therefore include all these elements.

I-2. — It is always difficult to draw up this balance sheet accurately owing to the

incertitude that exists as to the evaluation of certain factors, sometimes of considerable importance.

I-3. — The diversity of the accountancy methods makes it difficult to compare the balance sheets prepared by the different administrations, especially as regards the industrial amortisation of the fixed plant and rolling stock.

I-4. — As the total capital charges may exceed the operating costs in the case of electric traction, whereas they only represent a small fraction in the case of steam traction, fluctuations in traffic are capable of modifying radically the aspect of the balance sheet of electrification.

I-5. — Apart from special cases (suburbs of large cities, mountain lines, lines on which the limit of capacity has been reached, abnormally high fuel costs, etc.), electrification is generally economical only if money can be obtained at a low rate, if the electric power can be obtained at a favourable price, and if the traffic is proportionately heavier as the gradients of the line are easier.

I-6. — The economic considerations proper to the railway are not the only ones which may decide the electrification of a line : the decision may be the result of either considerations relating to the general economics of the country, or necessities of a technical nature quite apart from any question of finance.

The President (in German). — I ask the reporters present to express their opinion on this first part.

Mr. Huber-Stockar, *Reporter* (in German). — As a reporter, I would first of all like to say that I agree with the summaries Mr. Leboucher has just read, all the more so as, in my opinion, they reflect not only the ideas of all the different reporters, but also are an exact statement of the position.

Nonetheless, the careful reader will feel a certain disappointment, seeing that owing to the complexity of the circumstances that have to be taken into account, the reporters were not able to pronounce any precise and definite judgments on the economic value of electrification, as compared with steam operation.

I might say that the decision to electrify or not to electrify is less a matter of calculation, or a mathematical question, than a question of appreciation and a matter of courage and foresight.

These difficulties seem to me to have been brought forward by the summaries of the Special reporter, and I can only recommend their adoption as a whole. *(Applause.)*

Mr. Seefehlner, Austrian Federal Railways and Permanent Commission of the Association (in German). — Because of the great importance put upon the resolutions voted by the Congress, I would like to ask if it would not be better to reword paragraph I-5 of the summaries and make it a little more precise. It says that electrification is only economic when the rate at which money can be borrowed is low. I would like to know what is considered as money obtained at a low rate? This rate is very variable. There are lines which should not be electrified even when money can be obtained at 2 %, and others which can be electrified in spite of a rate of interest of 10 %. I should like the text to be modified so as to take into consideration, when studying the question from the economic point of view, not only the rate of interest, but also the ratio between the rate of interest and the intensity of traffic. Otherwise the States in which the rate of money is 10 % might say that according to the opinion of the Congress electrification is not advisable. Now, this is not our intention at all. We mean to say that a ratio should be estab-

lished between the rate of interest and the traffic.

Mr. Lajthay, Hungarian State Railways (in German). — I would like to point out in this connection that it is remarkable that the question of electrification is always studied so much more carefully from the economic point of view.

When we say that electrification is an improvement and modernisation of railway traction, the economic value should only be studied as in the case of other investments. I might quote, for example, the cost price of modern wagons, or better safety installations, or for putting up cables for low tension transmission lines, cases in which the economic question is never gone into with the same care as it is in electrification. In considering the improvement and modernisation of electrified lines, we should not, for this reason, apply such rigid rules to the study of the economic side of the question, seeing that certain resulting advantages can often not be stated in terms of money.

Mr. Huber-Stockar (in German). — In my opinion, the last speaker's remark is a very true one. For my part, I have often expressed such an opinion. But this cannot be made into an argument against the summaries, as it is stated in them that these factors, which cannot be expressed by figures, are frequently the decisive ones. Consequently I think that it is not necessary to alter the text of the summaries.

Mr. Seefehlner (in German). — In my opinion mention should be made of the fact that electrification is an efficacious means of combating road motor competition, especially from the point of view of speed.

The President (in German). — This is already taken into account in the summaries. In this same field we have in addition, with rail motor cars, a possibility capable of extension.

But, first of all, I would like to say a few words about Mr. Seefehlner's first remark. The point he stresses is, in fact, also contained in the summaries. It is clearly stated : « Apart from special cases (... mountain lines... etc. ». This should be a determining factor for the economic value. The expression : « Money obtained at a low rate » is not very clear but the idea of the economic value is in reality brought out when the reporter, Mr. Huber-Stockar, says : « Each electrification should as a rule improve the « profit and loss » account of the railway and should not in any event be a charge on it. It ought at least to be possible to anticipate such an improvement *. » This appears to be to the point as well as exact.

Are there any other remarks?

Mr. Besser, German Ministry of Communications, and Permanent Commission of the Association (in German). — I would like to make a suggestion about summaries 4 and 5. Summary I-5 says : « Apart from special cases... electrification is generally economical only if... and if the traffic is proportionately heavier as the gradients of the line are easier ». By an easy profile, a level line is meant. This is not what was really meant. The meaning intended was rather that the profile should be favourable for electrification. A careful reading of the text leads one to think that it is a question rather of mountain lines. Therefore, after « Streckenprofil » should be added : « starke Steigungen. »

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* Cf. the June 1932 *Bulletin of the Railway Congress*, page 858.

I also propose to rectify summary I-4 in the German version by replacing : « Trotzdem die für den Kapitaldienst... » by : « Da die für den Kapitaldienst... » which is closer to the meaning.

Mr. Leboucher (in French). — I think that there is a misunderstanding about the last sentence of summary 5.

Electrification is valuable above all from the point of view of saving coal. Now the lines with easy profiles and very heavy traffic are in actual fact those which really do consume the most coal, much more than the mountain lines.

I think the text should be kept as it is, because on the lines over flat country, for example between Paris and Orleans, which is a very easy line, the traffic is exceedingly heavy, and this is perhaps the line which has been the greatest success from the point of view of electrification, because of the considerable saving in coal which has resulted therefrom.

Mr. Besser (in German) — If we put « an easy profile » it is probable that the railway operator will conclude that only lines over flat country should be electrified. This is not the intention of the reporter. And in the example quoted it is without doubt the high speed which justifies the electrification.

To make the matter quite clear, it is necessary to make a distinction between these two different situations : on the one hand electrification may be justified because of the rapidity of the traffic even on the level, but on the other hand if the profile is mentioned, it is above all the mountain lines that can be electrified with profit.

Mr. Lajthay (in German). — The last observation which has been made proves that the situation should always be considered as a whole, and for this reason I think it is a mistake to speak of money at a low rate of interest.

There are circumstances in which the situation as a whole justifies electrification even when money is only obtainable at a high rate; it is a question of knowing if the intensity of the traffic bears any ratio to the rate of interest.

Mr. de Boysson, Paris Orleans Railway (in French). — I support the President's remarks and I propose the summaries be accepted as put before us. In fact, I think that the rate of interest is an element which should be taken into account equally with the intensity of the traffic. It is not the only element which should be considered, but it is one of primary importance.

On the other hand, the question of the actual economy of the electrification is not the only element to be considered. Paragraph 6 makes it quite clear that other considerations should be taken into account besides the economic considerations, although these should take the first place.

There are certain improvements in which these considerations have not been considered alone, but electrification leads to such high first costs in comparison with the expenditure for other modernisations of the railway that it is indispensable, if it is desired to electrify, to consider first of all the efficiency of this operation.

Apart from this factor, considerations relative to local installations, the rapidity of the service, etc., can have to be taken into account; but these are only secondary questions.

From the point of view of the profile, electrification is undoubtedly the most profitable on mountain lines; this is due to the fact that on such lines the coal

consumption, for the same amount of traffic, is higher than on lines over flat country.

It is therefore easier to justify, from the economic point of view, the electrification of a mountain line than that of a line on the level.

However the factor to consider in judging the saving due to electrification is the coal consumption. This is more or less proportional to the product of the index figure of the profile by the index figure of the intensity of the traffic.

It is therefore indispensable to maintain the idea that electrification of a line is only economical when the intensity of the traffic increases when coming onto the more easily graded sections.

The President (in German). — It has been suggested that instead of « money at a low rate » we should say « money at an appropriate rate » or some expression corresponding to this idea, to take into account the fact that electrification may be justified even in the case when money cannot be obtained at a low rate.

Does the Special Reporter agree to putting : « if money can be obtained at an appropriate rate »?

Mr. Seefehlner (in German). — Agreed.

As regards the traffic, we speak of the intensity of the traffic, we do not say it should be great or small, we make use of a very vague expression.

Mr. Leboucher (in French). — Could we not say : « if money can be obtained at an acceptable rate »?

— *Adopted.*

The President (in German). — I gather that summaries I-1 to 6 are approved with some very slight modifications.

In summary 4 we will make the rectification in the German translation, suggested by Mr. Besser. The French text will remain as it is.

In summary 5 which mentions the rate of interest, we will say : « ... if money can be obtained at an acceptable rate ».

Finally, where it speaks of easy gradients, we will replace these words by : « ... as the profile of the line is more favourable for electrification ».*(Adopted.)*

I will now ask Mr. Leboucher to read the second part of the summaries.

Mr. Leboucher :

II. — Under reserve of the special requirements of electric traction, the selection of the sites for the generating stations supplying power to electrified railway lines is governed by the same considerations as in the case of generating stations feeding ordinary distribution systems or large centres of consumption.

Mr. Huber-Stockar (in German). — I warmly recommend the adoption of this summary. The question of the site of the power stations might very well have been left out, as it is included in Question V as a whole.

The President (in German). — As no objections have been raised, *Summary II is adopted as presented.* We will now go on to the third part, about the *choice of the kind of current.*

III-1. — The choice of the kind of current for electric traction, formerly influenced by technical considerations, is today a problem of a purely economic nature.

III-2. — This choice can only be determined in each case by taking into account the whole of the conditions of the problem put forward, and by comparing the whole of the expenditure (operating costs and capital charges).

III-3. — The three-phase system appears unlikely to be used for new applications out-

side the zone where it is used at present, so that in the case of new electrifications the choice would appear to lie between direct current and single-phase current only.

III-4. — Although direct current has been adopted in recent years whenever it was not a question of extending an electrification already undertaken on a different system, or of electrifying lines closely connected with those already electrified on a different system, the two systems, direct current and single-phase current, appear to be suitable for future use in new electrifications outside their present fields of application.

The President (in German). — As the use of direct, three-phase, and single-phase current varies considerably in the different countries covered by the reports, I think that Members should take this opportunity to express their opinion on this point.

Mr. Lajthay (in German). — It is perhaps not advisable to mention only these three systems. It is possible and even probable that other systems may have to be added. As technicians, we would not only enumerate the existing systems, but also those to be looked forward to in the future. All the industrial firms and all the railways are endeavouring to find a way of supplying their system direct with 50-cycle current. Everywhere we thus come across attempts to find a system by means of which, without having need for power stations or distribution systems built especially for the railways, but with simple transformation stations, 50-cycle current can be used on locomotives. As in the future technical solutions may be found for this problem, we should say : « as well as the other systems to be used in the future ».

The President (in German). — Personally I do not think this is a very happy suggestion. At the present time there are only these three kinds of current. It goes without saying that single-phase current can also be used with a 50-cycle frequency. It may also be possible to increase to a considerable extent the voltage of the direct current. As for three-phase current, its use is limited to districts where it has already been used.

It is quite likely that in the future, which is not revealed to us, there will be other kinds of current, but the resolutions we vote now correspond to the present-day position, and I think that we can very well fall in with the summaries of the Special Reporter. If we wish to deal with what concerns the future, we will have to make some precise proposal on this subject.

Mr. Besser (in German). — By enumerating the three types of current, it seems as though everything had been said on the subject. The text of summary III is of such a nature as to lead us to believe that the technical evolution is complete and there remain only economic considerations to be examined. Now this is not the case. A distinction must be made between, for example, three-phase current used directly on the locomotive, as in Italy, or first of all transformed in some way.

The tendency of evolution is to transform three-phase current by means of rectifiers into single-phase or direct current. This possibility should not be lost sight of, as it would be a great advantage if the general distribution system of a country could be used directly for railway electrification.

Consequently, I suggest that we should add to summary III-1 the following sentence : « However the possibility should not be overlooked of some technical improvement which will make it possible to

use, for electric traction on the railways, current taken from the general three-phase distribution system. »

Mr. Mariani, Italian State Railways (in French). — I agree with the remarks made by the President, and as representative of the Italian Railways I would like to call your attention to the fact that the three-phase system which is extensively used in Italy, was first used there 30 years ago, that is at a time when this method was the only one possible for the operation of a system with heavy traffic.

The three-phase system continues to be extended in Italy in those districts where it has been used since the beginning, that is to say the lines which were not yet electrified but were situated in that part of the country where the three-phase system was extensively used are still electrified on the three-phase system.

This system has still great advantages in the case of lines with many gradients, such as we have in Italy, and on lines with heavy traffic.

We are about to electrify the southern and middle parts of the Italian Railway System with direct current because the technical development of this system will enable us to improve the electrification.

I would like to say, in addition, that the three-phase system has given us very good results, especially in the case of lines with heavy traffic and steep gradients.

Finally I would like to add that we do not want any modification in the summaries of the Special Reporter; these express very well the ideas of the Italian delegates on the system of electric traction.

Mr. Leboucher (in French). — I think everyone would be in agreement if a very slight modification were made to paragraph 3. We might say :

« The three-phase system appears unlikely to be used for new applications outside the zone in which it is already in use, so that in the case of new electrifications the choice would appear to lie at present between direct current and single-phase current only. »

— At Sir Henry Fowler's request, the statements of these last few speakers as well as the text proposed by Mr. Leboucher were translated into English.

Mr. Huber-Stockar (in German). — I would like to call attention to the following point. The reporter says that it is a question of the current in the contact line, whatever may be the method of production. The system Mr. Lajthay is speaking about would be the single-phase system, using one of the three phases which together form three-phase current. This is therefore a question of distribution of power, but not of the system. It would be a mistake to begin a long discussion about a matter already discussed at length at Rome. It was because of this that we, the reporters, defined the system.

Mr. Besser (in German). — I wish to state my agreement with the above and therefore I withdraw my proposal asking that in summary III-1 the words « purely economic » should be replaced by « usually purely economic ».

Mr. Huber-Stockar (in German). — I should also like to add that, in my opinion, it is not exact to say that the choice of the system is or can be a purely economic question. Undoubtedly, at the present time it is more of an economic nature than formerly, when it was partly a question of technical and industrial preparation. But it is certainly at the

present time not purely economic, if only because purely technical considerations have raised all the difficulties about which I have just spoken. I think therefore that you will agree to add to the end of summary III-1 : « ... are today only an economic problem and a question of suitability.

Mr. Lajthay (in German). — The last speaker has said that we are discussing not systems, but kinds of current. But when mention is made of single-phase current, this is understood to mean low-frequency single-phase current in the contact line and on the transformers and switches of the locomotive. Nobody would think of 50-cycle current on the distribution line and on the locomotive fitted with three-phase motors. In this connection I should like to say that when I last spoke I was too cautious in my statements. It is not merely a question of the future. Hungary has already electrified 306 km. (190 miles) with single-phase current at 50 periods, by using locomotives fitted with phase converters.

The President (in German). — By the expression « suitability » no doubt Mr. Huber-Stockar means « opportunity »?

Mr. Huber-Stockar (in German). — Yes, that was what I meant to say.

The President (in German). —I therefore propose to say : « ... purely economic considerations ».

Mr. Huber-Stockar (in German). — I will give you an example. When the railways were electrified in France, direct current was used without any hesitation. Economy was not considered. Is this an economic procedure? No. It is only a question of what was opportune. But if we have to give the administrations any indication, this is quite another matter, because we want to tell them what they ought to do and why.

Mr. Leboucher. — I think everyone would agree with the following text :

« The choice of the kind of current for electric traction, formerly influenced by technical considerations, is today a problem to be solved either by purely economic considerations or by special considerations. »

The President (in German). — I think that we should adopt the text proposed by Mr. Leboucher. *(Approved.)*

— *The first paragraph of the summaries of the IIIrd part is therefore adopted.*

I now submit for your approval the text of summary III-3 :

« The three-phase system appears unlikely to be used for new applications outside the zone in which it is already in use, so that in the case of new electrifications the choice would appear to lie between direct current and single-phase current only », as well as Part III as a whole.

— *Approved.*

Mr. Duquesne, Belgian National Railway Company (in French). — In Belgium the electrification of two large sections of line has been considered. It was found very difficult to get out a balance-sheet, as the reporter indicated.

But the technicians who had to deal with the schedules properly speaking also showed much hesitation in their choice of such and such equipment, fittings, etc.

The different points which require much technical discussion are in particu-

lar : Catenary lines; should single or double lines be used?

Should automatic adjustment or seasonal adjustment of the overhead lines be preferred?

Do other reasons than those of an economic nature decide the choice of the type of support for the overhead line (in concrete, rolled sections, Grey girders)?

It is very useful to have at one's disposal standard rules for mechanical calculation of the lines and for the calculation of the foundations for the supports.

What type of insulator should be chosen?

Should double or simple insulation of the overhead lines be adopted?

In the case of the rolling stock, what factors decide the choice of the type of suspension of the motor :

a) in the case of locomotives?

b) in the case of rail motor cars?

How do rail motor cars behave when working on lines supplied with 3 000-volt direct current?

Using this same system, in what part of the vehicle should the equipment of these rail motor cars be located?

As regards the substations, to what extent should spare plant be provided? (as a percentage of the usual power)?

Sectional posts : should the sectional posts be automatic or controlled by pilot wires?

I would like to ask the Congress to consider if it should not add to its programme the study of the best way of carrying out electrification (overhead lines, equipment, stand-by plant in the substations, etc.) and other technical questions which might be raised by the countries contemplating electrification or extensions to their electrified lines.

To support my suggestion, I would call to mind that in Paris, during the Electricity Congress in 1932, the General Reporter of the Electric Traction Section decided that the time had come to deal in Congresses with questions of standardisation and normalisation in the manner of carrying out electrifications.

It would be desirable to see that the Railway Congress is not deprived of the priority in dealing with these indispensable technical studies for the certain and complete success of electrifications.

Mr. Bals, Rumanian Railways (in French). — Seeing that the Rumanian State Railways are at the present time studying the electrification of one of their difficult mountain lines, which has reached the limit of its capacity, and that the technicians who are dealing with the matter have come up against the same difficulties as those pointed out by Mr. Duquesne, I quite agree with the wish he has expressed.

The President (in German). — In my opinion, this suggestion should be communicated to the Permanent Commission who can deal with it.

We now come to point IV : *Safety measures.*

Mr. Leboucher :

IV-1. — Apart from the safety measures in general use in all plants using electric energy, supplementary measures have been taken on electrified lines to protect the public and the staff against the particular dangers which the contact lines (trolley wire or conductor rail) and the electrical equipment of the locomotives and rail motor coaches may present.

IV-2. — The efficacy of these measures is proved by the few accidents which can be ascribed to the use of electrical energy for traction purposes.

IV-3. — Most of these accidents are the

result of a mistake committed by the victim, his imprudence or his negligence.

IV-4. — These accidents occur especially when the electrification is new, and principally affect the staff still insufficiently familiar with the steps to be taken to protect themselves, whence the necessity for specially looking after this part of the professional instruction of newly recruited staff, or staff temporarily employed, as well as of staff employed by contractors.

The President (in German). — I think if there is no objection, that we can adopt these summaries as meeting their object, as in the end they are interpreted more or less differently in every country.

— *Agreed.*

Before the meeting comes to an end, I should once more like to express in the name of the Section our very grateful thanks to Mr. Leboucher who so kindly presented Mr. Japiot's special report. *(Applause.)*

I also make use of this opportunity to express our thanks to Sir Henry Fowler, for his excellent report on Question IV, which I forgot to do when we last met. *(Applause.)*

Does anybody still wish to speak?

Mr. Murphy, Great Southern Railways, Ireland. — I wish to say a few words about the possibility of battery electrification of railways. Perhaps some of you here have heard of a battery invented by Professor Drumm. This battery is used by the Great Southern Railways of the Irish Free State — of which I am a Director — and we find that we obtain very good results.

The Drumm battery is an alkaline battery of very robust construction and long life. It has a very low internal resistance and can be charged and discharged at high rates. If suitable arrangements can be made for frequent charging it can give an output of from 20 to 40 watt-hours per lb. weight of battery per day.

Railway electrification by continuous contact can only be made economic for relatively heavy traffic lines. The Weir report on main line electrification for British railways indicated that for traffic densities below 2 000 000 trailing tons per mile of line per year, electrification costs exceeded steam costs and increased rapidly, so that electrification was uneconomic for these lighter traffic lines.

The Drumm battery, however, is capable of providing the same type of service as continuous contact electrification. The accelerations and speeds are similar to those obtainable by continuous contact electrification. Furthermore, it has a very long life and the renewal and maintenance charges are relatively low. Consequently, the Drumm battery should enable electrification to be carried out on an economic basis for traffic densities lower than two million tons per mile of line per year, which have been indicated as the economic limit in the Weir report.

The Drumm battery, therefore, may be regarded as providing a solution for the electrification of lighter traffic lines and can be used in conjunction with continuous contact electrification on the heavier density portion of any railway system.

I do not know whether any one here is interested in the Drumm battery, but if so, I shall be pleased to give all information desired on this subject.

Mr. Duquesne (in French). — I would be very grateful if foreign delegates would give me any information on the points I mentioned above, and could tell me where to find the detailed information I require.

— The Meeting was then closed.

DISCUSSION AT THE PLENARY MEETING.

24 January 1933.

PRESIDENT : H. E. IBRAHIM FAHMY KERIM PASHA.
GENERAL SECRETARIES : MESSRS. P. GHILAIN, YOUSSEF RISGALLAH BEY, Dr. I. G. LEVI and FOUAD HASSIB BEY.
ASSISTANT GENERAL SECRETARIES : Sir HENRY FOWLER and Mr. P. WOLF.

Mr. Ghilain, *General Secretary*. — We now pass on to the examination of Question V. The summaries adopted by the 2nd Section have appeared in No. 3 issue (23 January) of the *Daily Journal of the Session*.

Mr. Ghilain reads Summaries I-1 to I-6.

Mr. Ghilain. — I have received, as regards the wording of paragraph I-5, a request for its modification, from Mr. Leboucher, the special reporter.

Mr. Leboucher asks that the last part of the sentence be worded as follows : « if the traffic is proportionately heavier as the profile of the line is easier ».

Sir Henry Fowler, Assistant General Secretary (in English). — If a modification should be found necessary, we might for the time being concentrate on the French text with the reserve of bringing the final text in the two other languages into agreement with it.

Mr Ghilain. — The modified French text will therefore be as follows :

« I-5. — En dehors des cas spéciaux (banlieue des grandes villes, lignes de montagne, lignes arrivées à la limite de leur capacité, prix anormalement élevé du combustible, etc.), l'électrification n'est généralement économique que si le loyer de l'argent est acceptable, si l'énergie électrique peut être obtenue à un prix favorable et si le trafic est d'autant plus intense que le profil est moins accidenté. »

— *Adopted.*

Mr. Ghilain then reads the other summaries.

The President. — Are there any remarks?

Mr. Fiori, Permanent Commission of the Association and Italian State Railways. — I should like to modify slightly the wording of summary III-3 by saying « outside the *zones* » (plural) instead of « outside the *zone* ».

The President. — As no objection to this modification is being raised, we will consider it as approved.

The final text of the summaries of Question V is thereby completed.

Summaries.

I. *Electrification from an economic point of view.*

« I-1. Electrification is in general « characterised, from the economic point « of view, by a heavy increase of the « capital charges, by savings. frequently « considerable, on the operating costs, « and finally by indirect advantages

« which may in certain cases play the « predominant part; the balance sheet « of the electrification should therefore « include all these elements.

« I-2. It is always difficult to draw « up this balance sheet accurately, owing « to the incertitude that exists as to the « evaluation of certain factors, some- « times of considerable importance.

« I-3. The diversity of the accountancy « methods make it difficult to compare « the balance sheets prepared by the « different administrations, especially as « regards the industrial amortisation of « the fixed plant and rolling stock.

« I-4. As the total capital charges may « exceed the operating costs in the case « of electric traction, whereas they only « represent a small fraction in the case « of steam traction, fluctuations in traf- « fic are capable of modifying radically « the aspect of the balance sheet of elec- « trification.

« I-5. Apart from special cases (su- « burbs of large cities, mountain lines, « lines on which the limit of capacity « has been reached, abnormally high fuel « costs, etc.), electrification is generally « economical only if money can be ob- « tained at an acceptable rate, if the elec- « tric power can be obtained at a favour- « able price, and if the traffic is propor- « tionately heavier as the profile of the « line is easier.

« I-6. The economic considerations « proper to the railway are not the only « ones which may decide the electrifica- « tion of a line : the decision may be « the result of either considerations re- « lating to the general economics of the « country, or necessities of a technical « nature quite apart from any question « of finance.

II. *Selection of sites for generating stations.*

« II. Under reserve of the special re- « quirements of electric traction, the se- « lection of the sites for the generating « stations supplying power to electrified « railway lines is governed by the same « considerations as in the case of gener- « ating stations feeding ordinary distri- « bution systems or large centres of con- « sumption.

III. *Choice of the kind of current.*

« III-1. The choice of the kind of « current for electric traction, formerly « influenced by technical considerations, « is today a problem to be solved either « by purely economic considerations or « by special considerations.

« III-2. This choice can only be de- « termined in each case by taking into « account the whole of the conditions of « the problem put forward, and by com- « paring the whole of the expenditure « (operating costs and capital charges).

« III-3. The three-phase system ap- « pears unlikely to be used for new ap- « plications outside the zones in which « it is already in use, so that in the case « of new electrifications the choice would « appear to lie between direct current « and single-phase current only.

« III-4. Although direct current has « been adopted in recent years whenever « it was not a question of extending an « electrification already undertaken on « a different system, or of electrifying « lines closely connected with others al- « ready electrified on a different system, « the two systems, direct current and « single-phase current, appear to be suit- « able for future use in new electrifica-

« tions outside their present fields of « application.

IV. *Safety precautions, etc.*

« IV-1. Apart from the safety meas- « ures in general use in all plants using « electrical energy, supplementary meas- « ures have been taken on electrified « lines to protect the public and the staff « against the particular dangers which « the contact lines (trolley wire or con- « ductor rail) and the electrical equip- « ment of the locomotives and rail motor « coaches may present.

« IV-2. The efficacy of these meas- « ures is proved by the few accidents « which can be ascribed to the use of « electrical energy for traction purposes.

« IV-3. Most of these accidents are « the result of a mistake committed by « the victim, his imprudence or his ne- « gligence.

« IV-4. These accidents occur especial- « ly when the electrification is new, « and principally affect the staff still « insufficiently familiar with the steps « to be taken to protect themselves, « whence the necessity for specially look- « ing after this part of the professional « instruction of newly recruited staff, or « staff temporarily employed, as well as « of staff employed by contractors. »

* * *

Mr. WITHINGTON, the American Reporter, who was unable to attend the discussions of the Congress, has pointed out that Summary III-4 does not exactly state the conditions existing in America.

For instance, in the case of the Great Northern Railroad, in the northwestern part of the U. S. A., a decision was made to electrify on the basis of single-phase power distribution, replacing the early three-phase electrification on that railroad. This was not an instance of extending a previous electrification of a single-phase system, as it was necessary to discard practically all the original equipment. As another example : The Reading Company's single-phase electrification recently completed at Philadelphia, is an entirely independent project not connected with any previously existing electrification.

Furthermore, the Pennsylvania Railroad in extending its electrification between New York and Philadelphia, proceeded on the basis of single-phase distribution in spite of the relatively elaborate D. C. system originally installed, and the New Haven Railroad also having had early experience with direct-current, adopted the single-phase system for its main line electrification.

Note by M. S. COOVER,

Professor, University of Colorado, Boulder, Colorado.

Mr. Withington has presented a very excellent and comprehensive treatise on the electrification of railways from an economic point of view. The problems surrounding the selection of the kind of current for a proposed railroad electrification project, or, the « system » of electrification, as it is sometimes termed, has always been a matter of deep interest to me whenever a new installation is contemplated. The many factors to be considered and coordinated are outlined by Mr. Withington in Part III of his paper.

The particular and fundamental reasons for projecting any railroad electrification program may be readily summed up in the operating and the economic benefits expected to be derived from the replacement of steam with electric drive. It appears that there are two major obstacles that are blocking progress toward a more intensive program of electrification, namely: the large amount of capital required, also the element of reluctance to proceed with a program on account of the fact that no authoritative or arbitrary standard « system » has as yet been adopted. The latter element is naturally associated with grave concern as to whether an investment made today will fall within that ultimate standardized system or will be considered as being in an obsolete group altogether too soon.

It is perhaps the result of a natural and orderly sequence of development that there are now eleven different systems of electrifications in operation when kind of current, variations in voltage and in frequency are included A regrettable fact is that while these eleven systems all may be applied, for example, in different regions or zones of a single carrier, the electrical equipment in one zone would not be able to operate at all in any other zone or at best under intolerable disadvantages.

It would eminently be unwise to invite standardization in this phase of transportation until such time as it may appear certain that to establish the ultimate will not bring on misfortune and prohibitive costs to make changes at a later time. Something close to that ultimate standard ought to be reached or decided upon through the combined effort of some international cooperative group of representatives if a maximum of direct benefits to all concerned are to be realized. Much capital has already been invested in the various systems with seeming disregard for the fact that there ever may be a need for interchange of equipment among the carriers.

In arriving at a choice of that ultimate system, it would appear that fundamentally and economically it should be that system which would be most favorable to initial cost, reliability, operation and maintenance cost, fixed charges cost and reliability of power supply, coordination of power and intelligence circuits, earth currents, and future expansion including the possible necessity of materially raising schedule speeds. The ultimate standard might call for some modification on the different continents, but if applied universally to each separate continent it is believed that remarkable progress would ensue.

[625. (0 & 665. 882]

QUESTION VI :

All-metal rolling stock : Carriages and Wagons. Use of light metals and alloys. Use of autogenous welding.

Preliminary documents.

1st report (America, Great Britain, Dominions and Colonies, China and Japan), by Mr. H. N. Gresley. (See *Bulletin*, August 1932, p. 1467, or separate issue No. 22.)

2nd report (all countries except America, Great Britain, Dominions and Colonies, China, Japan, Germany, Bulgaria, Denmark, Finland, Norway, Netherlands and Colonies, Rumania, Sweden, Czechoslovakia and Turkey), by Mr. R. Mariani. (See *Bulletin*, October 1932, p. 1839, or separate issue No. 34.)

3rd report (Germany, Bulgaria, Denmark, Finland, Norway, Netherlands and Colonies, Rumania, Sweden, Czechoslovakia and Turkey), by Mr. E. Dähnick. (See *Bulletin*, November 1932, p. 2059, or separate issue No. 30.)

Special Reporter : Mr. E. Dähnick. (See *Bulletin*, January 1933, p. 73.)

DISCUSSION BY THE SECTION.

Meeting held on the 25 January 1933 (morning).

Mr. E. STUDENT, President of the 2nd Section, in the Chair.

— The Meeting is opened at 9.30.

The President (in German). — I call upon Mr. Dähnick, the *Special Reporter*, to give us a brief commentary on his report.

Mr. Dähnick, *Special Reporter* (in German). — Gentlemen, before we begin to examine the different summaries, I would like to put briefly before you the more important points in the reports presented to the Congress.

In the case of passenger carriages, the summaries adopted at the Madrid (1930) Session on all-metal construction have been fully confirmed. There has been a considerable increase in the number of Administrations who have definitely gone over to the use of steel construction. Moreover, an appreciable increase in the number of all-metal vehicles put into service has been observed. This result can be qualified as remarkable when we consider the short time that has elapsed and the general economic crisis.

Side by side with the present method of construction of all-metal vehicles, we must take note of the very important results obtained in the field of light construction. The use of light metals on the one hand and, on the other, of welding, and the methodical reduction of the weight of the different parts have made it possible to obtain great advantages. The saving of weight obtained reaches and even exceeds 20 %.

In this way, it has been possible to increase the speed not only of rail motor cars, but also of passenger trains, without appreciably increasing the operating costs. It is hoped that in this way the railway will be able to meet road motor competition effectively, without greatly increased expenditure.

In the case of goods rolling stock, metal construction also gives considerable advantages. The increase in strength, safety, and length of life, has the effect that, as in the case of passenger vehicles, metal construction will continue to develop favourably.

I will now read you the summaries.

The President (in German). — I suggest that the Meeting should examine in the first place the question of *passenger carriages*, and afterwards that of *goods wagons*.

Mr. Dähnick then read in German the summaries 1 and 5 relating to *passenger vehicles*. The English text is as follows:

A. — *Passenger carriages.*

1. The favourable results obtained during the last three years with all-metal passenger coaches confirms the summary of the Madrid Congress, wherein the following special advantages were emphasized:

Greater safety in case of accident;
Favourable tare weight of the vehicles;
Possibility of mass production;
Good interior appearance and arrangement.

2. Results so far obtained appear to authorize favourable expectations as regards the life of the vehicles, maintenance costs and redemption of the original capital cost. They justify the expectation that all-metal carriages will prove themselves and produce definite savings, especially in those countries in which the conditions for their use are most favourable.

3. The method of construction in which the underframe and the body framing are built as one unit which absorbs the forces developed as a whole, the weight being reduced at the same time, has given further satisfaction. In all-metal construction this method is used almost exclusively.

4. By the use of high-grade steels and by the substitution of welding for riveting, appreciable savings in weight, as compared with wood or riveted steel carriages, can be effected.

5. The use of light metals and alloys can also reduce the weight appreciably and therefore offers advantages in certain structural parts under specified conditions, in spite of their high price. Conclusive evidence as to their behaviour over a long period of time is not yet available. The Congress recommends the use of these materials to be further investigated.

Mr. Gresley, Reporter. — Unfortunately, since the Congress was held in Madrid, in the English speaking countries, on which I am reporting on this question, the progress made in the steel construction of carriages, has not been so great as in Germany. This is probably due to the depreciation of the Railways and to the great economies which have to be exercised ; therefore, fewer carriages have been built as fewer are required.

As regards experiments with carriages, there is a divergence of opinions as regards corrosion of steel carriages. This is probably due to climatic conditions in England. From these experiments we

certainly have indications that we are going to have trouble with corrosion of panels. However, the cost of replacing panels is not going to be a very expensive item.

At Madrid, some of the members may remember that I pointed out, that in England the traffic requirements are such that carriages have to be built with doors for each compartment. Therefore the side of the carriage cannot be made continuous, as in the case of the Continental stock. We must build our carriages to the requirements of the Traffic Department, and it is to be regretted that long continuous sides, is a design not acceptable to our Traffic Officers.

I referred in my paper to cast aluminium. Since the paper was written, I have built a carriage with steel underframe and steel body frame, but the whole of the sides and ends, and main doors are all made of cast alluminium. The result has been a reduction in weight of about 6 %. Perhaps the weight could be further reduced by welding the underframe instead of riveting this.

I have some photographs of the carriage under construction and completed. Owing to the fact that the carriage was only finished about two weeks ago, I only have one set of photographs, and will hand these to the President. The President can hand these photos round, if he thinks fit, or examine them after this discussion.

There is just one point I would like to refer to, i. e. the question of cost. I have no details as to the cost of the carriage. Obviously it will cost more on account of the aluminium employed. It must be remarked, however, that the scrap value — when the vehicle comes to be broken up, will be higher than if it had been entirely made of steel.

As far as the recommendations have been read out, I agree with them entirely.

Mr. Renevey, Paris, Lyons & Mediterranean Railway (in French). — Like Mr. Gresley, I quite agree with the summaries of the Special Reporter which seem to me to give a very exact account of the present situation as regards the construction of metal carriages.

I have, however, a word to say on the subject of summary 3, dealing with the method of construction.

We agree with the reporter on the fact that the body of the vehicle should take its part in the strength, but some time ago we made trials to ascertain the stress in the metal of the members of a vehicle built according to the designs of the « Office Central d'Etudes de Matériel de Chemins de fer », a carriage described in the report of my colleague Mr. Mariani. We found that with the weights and considerable overloads of the carriage, the static stress in the metal in the members, did not exceed 2 kgr. per mm^2 (1.27 Eng. tons per sq. inch).

From the static point of view, these carriages, therefore, are of great strength.

Carriages, however, are destined to undergo not only static, but also dynamic stresses.

The experience of several accidents has shown us that it is necessary to introduce a special form of construction of certain parts.

At the Madrid Congress, I had the occasion to point out that, up to that time, we had never had any case of one coach being driven into another. Since then however we have had such an accident, in which a carriage with a wooden frame penetrated deeply into a metal carriage, because the wooden body being demolished, the underframe of the wooden carriage acted like a knife.

This led us to conclude that the ends of carriages should be particularly well reinforced, a conclusion which, in my opinion, might profitably be included in summary 3.

Indeed, in the case of very violent shock, we have found, in practice, that the centre of the carriage is never deformed. Even under the most severe shocks the lights in the compartments are not broken.

It may happen, however, that when the end of the carriage is not sufficiently strong, it may be driven in by the underframe of another vehicle.

I think, therefore that it would be a good thing to call attention to the need for reinforcing the ends of carriages; we had to strengthen considerably our latest types in this way, when building them.

Mr. Dähnick (in German). — Mr. Renevey might perhaps suggest a text taking his observations into account.

Mr. Mariani, Reporter (in French). — The Italian Railways began to build metal carriages in 1922, to the number of 150, which were put into service that same year.

In the construction of these carriages we adopted countersunk riveting, and I should like to draw your attention to this fact, seeing that on many railways riveting with visible rivet heads is being adopted because it is feared that countersunk rivets have certain drawbacks.

In our carriages, the countersunk rivet has given complete satisfaction, with marked advantages in particular as regards painting as well as the cleaning of the outside of the carriages.

As regards corrosion, we have very carefully examined the metal carriages in service since 1922, and have found that they are standing up very satisfactorily.

Among the first carriages we built, to the number of 150, we tinned the joints of a certain number of carriages to prevent water leaking in, while in the case of the other 75 this tinning was not used.

In both cases, no water has got in, and we therefore consider that with careful riveting there is no fear of damage from rain.

As regards the point raised by Mr. Renevey, I would like to say that our carriages were built from the first with very strong pillars in the outer ends and that we have fitted these carriages with buffers of such a kind as to make telescoping more difficult. Even in the few cases in which a carriage mounted the buffers of the next carriage, the outer end of the latter did not give way. We have — I am sorry I have not got them with me — photos of accidents in which can be seen that the end pillars have been completely torn, but they have stood up, i.e. in the next partition, behind which was located the lavatory, everything remained intact.

When the first carriages were designed, we estimated that their maintenance and repairs — especially in cases of accident — would be more costly than in the case of wooden carriages. However, experience has proved that, even in the cases of serious accidents, the part of the carriages which is seriously damaged is usually small and that repairs can be quickly carried out with little cost by cutting away the damaged part and replacing it by a new partition, by autogenous welding. This frequently occurred.

It has even been found that it is easier to repair metal carriages after accidents than wooden ones.

In the case of our carriages with end doors, we had a case in which a wagon collided with the carriage beyond the end door, where the carriage widens out. The

pillar was completely knocked out of shape but it was still possible to open and shut the door by its lock perfectly well, though 4 inches away the damage was very serious.

Mr. Dähnick (in German). — I am glad you agree with the summaries. I would like to remark that it was particularly easy to draw up these summaries with the excellent reports of Messrs. Gresley and Mariani before me.

I am very interested to learn that the English railways have decided to go in for light metal construction on a large scale. On our side, we hope that this method will bring us many advantages, especially when the cost of light metals is lower.

On the Berlin Metropolitan Railway we have placed into service carriages in which the parts subjected to great stress are in steel, and the other parts in light metal.

The example quoted by Mr. Renevey, i.e. that in the case of collision the metal carriages can also be damaged, has been confirmed in our experience. This is why for some time we have used what is known as the « Rammkonstruktion » type, consisting of steel pillars of 200×120×16 mm. (7 7/8 in.×4 3/4 in.×5/8 in.) section. This method of construction very successfully proved its value in the particularly violent collisions at Jüterborg and at Düren. For example, there were 41 passengers dining in the restaurant car, who escaped with slight bruises, while there were 21 people killed in the next carriage.

I propose the following addition to summary 3 :

« In order to increase the strength in the case of collision, the so-called « Rammkonstruktion » type should be used for the ends. »

Mr. Renevey (in French). — In my opinion it would be better to adopt a quite general formula and to say that it is well to use particularly strong ends.

I propose the following text :

« Experience has shown that it is necessary to give special attention to the strengthening of the ends of the carriages, in order that, in case of collision or overriding, they should offer the greatest possible resistance. »

I have said « ends » because not only the body end, but also the underframe which sometimes undergoes very violent shocks, must be very strong.

The Americans have set us a good example in their large steel vestibules which are carried back almost as far as the body bolster.

Mr. Tevfik Fazli, Turkish State Railways (in German). — When the question arose of putting metal carriages into service in Turkey, it was feared that the heat would be unbearable during the hot season. You will be interested to learn that we took temperature records in closed carriages, with the windows shut, and with the windows open, when the train was standing and when it was running, in the sun and in the shade. The difference of temperature between wooden and metal carriages varied from 1/2 to 1 1/2° C. The result of these tests was that we had no hesitation in adopting metal stock.

Mr. Knight, Egyptian State Railways. — I should like to ask what the sun temperature was. We have made experiments on the Egyptian State Railways and found the difference to be 9° C. in the sun temperature of 71° C.

Mr. Tevfik Fazli (in German). — The records were taken with a sun tempera-

ture of 45 to 48° C., and 32 to 35° C. in the shade, as far as I remember.

Mr. Duchatel, Est Railway, France (in French). — Just two words to confirm the observations made. We have two types of metal carriages, the construction of which is very different : the main line carriages which are lined out inside, and the suburban carriages which are not lined out.

In the main line carriages we have not found the temperature to be any higher than in the case of our old wooden carriages. On the other hand in the suburban carriages, which are not lined out, during some *very hot* days last year, we recorded rather high temperatures.

Mr. Bloch, Paris-Orleans Railway (in French). — We are very interested in the reports presented. Mr. Gresley's remark that the saving in weight obtained by the use of aluminium alloy castings is 5.6 % is particularly interesting.

On the other hand, Mr. Dähnick, in his interesting report, gives some very considerable savings in weight due to welding. He states that a riveted carriage, which weighed 47 tons, was reduced to a weight of 40.1 tons after a number of operations, and in particular through welding, the decrease in weight being 6.9 tons, i. e. about 15 %.

In his report, Mr. Dähnick points out that this saving is due to various causes, some of which he enumerates. He points out, in particular, that the window frames were modified, which saved 250 kgr. (550 lb.) ; thinner heating pipes were used, and this saved 550 kgr. (1 210 lb.) ; other savings in weight amounting to 3 000 kgr. (6 600 lb.) were obtained by the use of alkaline train lighting batteries.

This accounts for about 1 ton out of the 7 tons given (6.9 t.).

We would be very grateful to Mr. Dähnick if he would give us further details about the way in which his trial carriages were built so as to obtain a saving in weight of 15 %.

Mr. Dähnick (in German). — In order to reduce the weight of the carriages, we adopted first of all light-metal construction. The use of light metals and light alloys automatically obliged us to reduce certain parts to their minimum dimensions so as to reduce the cost price. This method was applied when building rail motor cars and passenger carriages. With steel, it was not so important, because the cost price is lower. We now systematically use welding for all parts and have everywhere eliminated useless weight. On page 2095 (*English edition*) of my report, you will find a list of the parts the weight of which has been reduced; I will read it through quickly :

1. By the use of lighter parts such as windows, heating, supports for luggage racks, lighting equipment, etc. . .. about	2.20 t. =	4.7 %
2. Welding of type III heavy bogies . . . . . about	1.18 t. =	2.5 %
3. Welding of body to underframe . . . . . about	2.50 t. =	5.3 %
4. Use of high-grade steel about	1.02 t. =	2.2 %
5. Use of a new wood composition which we call « Histoxyl » . . . about	1.00 t. =	2.1 %
Total weight saved :	7.90 t. =	16.8 %
The reductions have also led us to obtain indirect weight savings because they enabled us to make use of the type III light Görlitz bogie instead of heavy bogies. Whence a saving of . . . . . about	2.60 t. =	5.5 %
Grand total :	10.5 t. =	22.3%

of the whole weight of the carriage.

I spite of the saving in weight obtained, the carriages look exactly the same as before; their dimensions have remained identical though their weight has decreased from 47 t. to 36.5 t.

In the case of the new rail motor cars, the construction was redesigned on similar lines, and in this way weights, which formerly would have been considered impossible, were obtained. Later on, it will perhaps be possible to make the same savings with all-steel construction as with the use of light metals and still further increase the strength of the vehicles.

Light metals have a strong tendency to age. In 5 or 6 years they may perhaps show defects which were not looked for.

In my opinion real progresss means light and strong all-steel construction.

Mr. Forte, Italian State Railways (in French). — I should like to say a few words about the use of autogenous welding in the construction of metal rolling stock.

The report of my German colleague stresses the advantages of welding when used in a general manner in the construction of metal carriages, as well as the difficulties that had to be met.

I think it may be useful to point out that with us also, at the Experimental Institution of the Italian State Railways, we found a greater reduction in the elastic limit and a more definite character of brittleness in the added metal in the welded parts broken in service.

Such defects were due to the fact that a large amount of carbon, manganese and silicon was lost during welding.

On the contrary in the case of special alloy steels, such as for example molybdenum-chromium-iron, or molybdenum-chromium-nickel-iron, etc., used as welding metal, it was found that they kept their special composition almost completely, and consequently their mechanical characteristics.

The defects which I have mentioned can consequently be eliminated very easily by using electrodes made of these special steels, and I think that a better knowledge of such phenomena is likely to extend the use of welding in rolling stock.

The President (in German). — As no one else wishes to say anything, I take it that everyone is agreed with the summaries as presented by the Special Reporter with the addition to summary 3, proposed by Mr. Renevey.

It is understood that, if need be, the wording of the translations of this additions will be altered, the meaning of Mr. Renevey's amendement being maintained. (*Agreed.*)

We will now pass on to the second part dealing with *Goods Wagons*. I will ask Mr. Dähnick to read the summaries relating to this part.

Mr. Dähnick read out the summaries as follows :

B. — *Goods wagons.*

1. Metal construction has special advantages over wood for open goods wagons :

Greater strength;
Greater safety in service;
Longer life;
Lower maintenance costs.

2. Under given climatic and operating conditions covered goods wagons, whether of the all-steel type or of composite construction in which the underframe only is all-steel, are used successfully.

3. All-steel construction for special coal, coke, and mineral wagons is advantageous.

4. By substituting welding for riveting, appreciable reductions in weight can be effected.

5. The use of copper bearing steels affords an efficient protection against rust.

Mr. Bals, Rumanian Railways (in French). — As far as all-metal wagons are concerned, I would like first of all to ask the opinion of the Section about their general safety, and in particular about the method of building the brakesman's shelter on these wagons, this last question being one that interests those countries which have not yet adopted the continuous brake.

As far as I remember, Mr. Mariani mentioned wooden shelters in his report.

I should say that we also have all-metal tank wagons with wooden shelters.

I should like to know whether metal construction of these shelters can be recommended as affording additional safety for the brakesmen.

Mr. Mariani (in French). — The Italian Railways have a large number of all-metal open top wagons : these are coal wagons, in which we have retained the wood construction for the brakesman's shelter.

For the greater safety of the staff it is absolutely necessary to make the shelter very strong. We have never thought of making it in steel, seeing that owing to temperature conditions it would have to be made with a double wall, which would increase the weight of the vehicle.

We also have 1 000 flat wagons. Most of these are fitted with the hand brake and the brakesmen's shelters are of wood.

We have, moreover, built covered all-steel wagons welded throughout. Trials are still being carried out in connection with this method of construction. Even in these wagons we have kept the wooden shelter, precisely in order not to increase excessively the weight of the wagons.

On the other hand the question loses some of its interest seeing that we shall shortly have to fit the continuous brake to all our stock.

Mr. Renevey (in French). — I quite agree with what Mr. Mariani has just said.

In France we have had metal shelters on all-steel wagons, but at one time some protests which have since calmed down were raised about the comfort of these shelters, particularly in Winter.

There is another point in the summaries upon which I think the Special Reporter has been too affirmative : this is point 5 :

« The use of copper bearing steels affords an efficient protection against rust. »

In France, we have also largely used copper bearing steels. In have found that opinions on their intrinsic value were not at all unanimous; this is why I would like to say that the opinion of the Special Reporter is perhaps too categorical. It seems to me, moreover, that the quality of the steel properly speaking certainly plays the principal part from the point of view of corrosion.

As far as the question of corrosion is concerned, I would like to ask Mr. Dähnick whether the oxide of which he speaks in his report is lead or iron oxide ?

Mr. Mariani (in French). — My colleague Mr. Bals, asked a very definite question as to metal wagons being safer.

For my part, I consider that metal wagons, from certain points of view, for the protection of the load, have greater safety, especially as regards the roofs being watertight.

In Italy, we have many wooden wagons whose roofs also are of wood, Although the roof appears to be in perfect condition it frequently happens that the rain gets in and damages the contents. On the other hand we have, even on wooden wagons, metal roofs, and in this case damage due to rain getting in is rare.

Mr. Bals (in French). — I thank Mr. Mariani for his explanations. I would like to remark that point 1 seems only to apply to open wagons, and in this case I should like to know why.

Mr. Mariani (in French). — Mr. Bals's remark is a good one.

It seems to me that the first summary could be given a wider signification by simply leaving out the word « open ».

The advantages of metal construction are not peculiar to open wagons, but also apply generally to covered and open wagons.

Therefore I propose that the word « open » should be left out.

Mr. Vandersypen, Belgian National Ry. Co. (in French). — I would like to add that on the Belgian railways we have made tests with a wagon roof made of zinc and this covering has up to the present given good results ; it resists rust very well, and at the same time prevents the goods from getting wet.

Mr. Bloch (in French). — Paragraph 5 of the summaries of the special report recommends that a metal should be looked for which will reduce as far as possible the consequences of rust.

I would like to point out in this connection that, in most designs,in deciding the thickness of the parts, the fear of corrosion is the determining factor.

Mr. Dähnick has told us that in Germany the weight of the vehicle has been considerably reduced. I conclude that particular attention has been given to the way in which the metal parts are painted.

In spite of this, it is certain that the thicknesses used in building are too great because the corrosion which might occur and the resulting loss in thickness have to be allowed for.

During the last few months, however, a new method of construction has been discovered : this is the process using welded units in rustless steel invented by Budd of Philadelphia. As Budd is sure that he has not to make allowance for rusting, he has been able to use bent plates only 1 mm. (0.039 inch) thick.

In this way the parts, when assembled, weigh very little per unit of length.

Would it not be useful to suggest in the summaries — I well know wishes only cannot be expressed — that in the future the steel makers produce rustless steel at such a price that it can be used generally in the construction of carriages.

In this way the metal carriage would be considerably lightened.

Mr. Dähnick (in German). — First of all replying to Mr. Renevey's question, I must tell you that we use red lead for goods wagons, but this causes difficulties from the point of view of the staff because of the risk to health the use of lead paint involves. Consequently red lead paint is being used provisionally.

In Germany we have a few old iron wagons. Latterly we have not built goods wagons of steel. But now, owing to the saving in weight, that can be obtained by welding, we are about to build the first wagons of this kind.

I agree with Mr. Mariani that the word « open » should be deleted.

To go back to Mr. Renevey's suggestion, perhaps summary 5 might be reworded as follows : « The use of better-quality steels and copper bearing steels provides a relatively good and economical protection against rust. »

There is also an anti-rust product called « Nirosta » which is, however, too expensive for goods wagons.

Finally in order to satisfy several delegates, the words : « ...in which the frame

only, and if need be the roof, is of steel » might be added to summary 2.

Mr. Gresley. — With regard to the amendment suggested to Paragraph 1, I am entirely in agreement.

As regards paragraph 5, I agree with Mr. Dähnick that it is too emphatic — with regard to the use of copper bearing steels. It has not been definitely proved that it is a protection against rust. We have wagons made with copper bearing steel, and the results are by no means positive. There are indications that copper bearing steel is a protection against rust, but it is not as definite as these conclusions would lead one to think. On the Great Western Railway, England, which has a very large number of wagons engaged in dealing with the coal traffic from Wales, it has been found that ordinary mild steel is quite unsuitable for the construction of coal wagons. The life of a coal wagon in mild steel is something under 20 years. The Great Western Railway has used wrought iron, for many years past. They have iron wagons for coal traffic, which have been in service for over 40 years. Iron, of course, is much more expensive than steel in first cost, but iron is cheaper in the long run. From experiments carried out for some time, with copper bearing steels, the results do not indicate that it is going to be as good as iron.

The London & North Eastern Railway have a number of wagons also employed in the coal traffic, and experience with steel has been such that we still prefer wood construction for small wagons, and for the large capacity wagons we have to use steel, but are not yet satisfied that copper bearing steel will give a longer life. I suggest elimination of clause 5 altogether, and to add to clause 3 : « It is desirable that either iron, copper bearing or rust resisting steel should be used in the construction of coal wagons ».

In England the coal traffic is very big, as you know, and we have about 1 million wagons exclusively used in the transportation of coal; of this number 900 000 to 950 000 are of wood and 50 to 60 000 of metal.

Mr. Mariani (in French). — Mr. Dähnick proposed to add to paragraph 2 of the summaries the words : « ...in which the frame only, and *if need be the roof*, shall be of steel ».

I think it would be better to use a more general expression.

On many railways there are wagons in which even the body framing is of steel. By simply saying : « of composite construction », it will be clearly understood that it is a question of wagons in which there is some wood.

I propose therefore that we should say: « of composite construction are used successfully ».

Mr. Gresley. — I accept this proposition.

Mr. Renevev (in French). — I also agree to this.

I would like to say a few more words about Mr. Gresley's proposal to mention coal wagons.

I do not think that it is necessary to allude in our summaries to what can be transported in a wagon. It is certain that the method of constructing a wagon and the metal used in its construction should be adapted to the goods that will be transported in it.

Another example : we mention here welded metals, of all-metal wagons; I do not think that anyone would transport cattle during the summer in such wagons.

I think, on the other hand, that summary 5, as it is worded, is very general and refers as much to the body as to the frame.

I suggest that it should be completed in the following way :

« The use of iron, good quality steels or copper bearing steels is, amongst others, a good measure of protection against rust. »

In this way I include the iron which Mr. Gresley mentioned, and by the words « amongst others » indicate that there are still other ways of preventing rust, in particular suitable painting.

Mr. Gresley. — I think Mr. Renevey's suggestion is not strictly in accordance with experience. As I said previously, our experience is that copper bearing steel is not proved to be an efficient protection against rust. It affords some protection. I would not regard it as an efficient protection, it is yet to be proved, and I think it a bad move if this Congress would give its conclusion that copper bearing steel is a definite rust protecting steel. It is not proved, in England, that it is a rustless steel.

Sir Henry Fowler. — I wish to confirm Mr. Gresley's remarks with regard to copper bearing steel. My railway has tried it for over 12 years, and found it to be an improvement, but not of course, to the extent that a high priced « stainless » (chrome) steel would be.

I feel that the last paragraph is too strong as it stands. I am a member of the « Iron and Steel Corrosion Committee » in Great-Britain, dealing with this subject at the present time, and although results have not yet been published, I can confirm the remarks made by Mr. Gresley.

Mr. Duchatel (in French). — I would also like to say that the tests which we have made with copper bearing steels have not been very encouraging. We made trials with copper bearing steels both for locomotive parts and for wagon parts.

For certain locomotive parts we found an appreciable improvement, which seemed to us to justify the continuation of the use of copper bearing steel, in particular for the ashpans which wear out very quickly when made of ordinary steel.

Contrariwise, on the wagons, we did not obtain any results, and have given up the use of copper bearing steel, at least for the time being.

Consequently, I am also of the opinion that at the present time it is hard to decide definitely in favour of copper bearing steel as a method of protection against rust, and I would like to know if it would not be sufficient to say in the summaries : « When selecting the metal, we should take into account the fact that certain kinds of goods transported in the wagons can have a corrosive action against which it is necessary to take protective measures ».

Mr. Gresley. — May I suggest a means of overcoming the difficulty in modifying conclusion No. B-5, by saying : « Iron and copper bearing steels are less liable to corrosion than ordinary steel » ?

Mr. Renevey (in French). — It seems to me that the words : « steel of good quality » should be added.

I wonder if we might say : « The use of iron, of steel of good quality, and of copper bearing steel, appear to represent progress in obtaining protection against rust. »

Sir Henry Fowler. — What is meant by steel of « good quality » ?

Mr. Renevey (in French). — In France, we have observed — and I think in this matter we are not alone — that certain steels supplied 15 or 20 years ago oxidised very quickly, while others with the same characteristics, and which are 40 years old, are still in good condition. The latter was good-quality steel, while the other was of bad quality.

The President (in German). — Let us be content to state in summary 5 that we wish to eliminate bad quality steel. Apart from this everyone will be free to choose the steel which is the most suitable for avoiding corrosion. Opinions seem, in fact, divided on the definition of steel of good quality; some railways wish to use copper bearing steels. Mr. Renevey's proposal, therefore, seems quite correct to me.

Mr. Dähnick (in German). — Agreeing with Mr. Renevy, I think that it would be best to say : « The use of iron, steel of good quality, or copper bearing steel, would appear to be a good protection against rust. »

Sir Henry Fowler. — From a metallurgical point of view, may I say, that some steels are good, and some steels are bad from a point of view of resisting corrosion, but in some cases, some good steels do not resist rust, and some bad steels resist corrosion better than some good steels. We might say : « Iron, or appropriate steels », and leave the responsibility to everybody to determine what he thinks is an appropriate steel.

Mr. Dähnick (in German). — I propose to add the words : « of iron, of appropriate steels, or copper bearing steels » so that the summary will be worded as follows : « The use of iron or « steels of appropriate qualities and of « copper-bearing steel appears to be a « progress towards protection against cor- « rosion ».

Mr. Renevey (in French). — Instead of : « ... *progress* towards protection against rust » I should like to say : « an improvement ».

Mr. Dähnick (in German). — The final text would thus be :

« The use of iron, of appropriate qualities of steel and of copper-bearing steel appears to be an improvement in the way of protection against corrosion. »

The President (in German). — I may say that we have now an acceptable wording of the summaries. *(Agreed.)*

Before we end I would like to thank Mr. Dähnick and the Reporters for their summaries, so happy in their wording and so precise in their matter, that they have considerably aided our work.

The 2nd Section is meeting today for the last time. I should therefore like to thank the Secretariat for their valuable collaboration which has helped me in carrying out my duties. *(Applause.)*

Sir Henry Fowler. — I have been asked, and it is with great pleasure I do so, to express to you, Mr. President, our thanks for the excellent way in which you have presided over our meetings. Their success has been so largely due to the way in which you have caused the business to be conducted.

I do so with all the greater pleasure because at Berne, 22 years ago, I also had the honour to express the thanks of the Section to the then President. *(Applause.)*

— The meeting then closed.

DISCUSSION AT THE PLENARY MEETING

held on the 30 January 1933 (morning).

H. E. IBRAHIM FAHMY KERIM PASHA IN THE CHAIR.

GENERAL SECRETARIES : Messrs. P. GHILAIN, YOUSSEF RISGALLAH BEY, Dr. I. G. LEVI and FOUAD HASSIB BEY.

ASSISTANT GENERAL SECRETARIES : Sir HENRY FOWLER and Mr. P. WOLF.

Mr. Ghilain, *General Secretary*. — We will now take Question VI of Section II. The text of the summaries has been published in the *Daily Journal* of the 26 January.

— *These summaries were then read.*

The President. — Are there any remarks about this text?

— As there are no remarks the summaries will be considered as adopted.

Summaries.

« A. — *Passenger carriages.*

« 1. The favourable results obtained « during the last three years with all- « metal passenger coaches confirm the « summary of the Madrid Congress, « wherein the following special advan- « tages were emphasized :

« Greater safety in case of accident;
« Favourable tare weight of the ve- « hicles;
« Possibility of mass production;
« Good interior appearance and ar- « rangement.

« 2. Results so far obtained appear to « authorise favourable expectations as « regards the life of the vehicles, main- « tenance costs and redemption of the « original capital cost. They justify the « expectation that all-metal carriages will « prove themselves and produce definite « savings, especially in those countries « in which the conditions for their use « are most favourable.

« 3. The method of construction in « which the underframe and the body « framing are built as one unit which « absorbs the forces developed as a « whole, the weight being reduced at « the same time, has given further satis- « faction. In all-metal construction this « method is used almost exclusively. « Experience has shown that it is neces- « sary to give special attention to the « strengthening of the ends of the car- « riages, in order that, in case of colli- « sion or overriding, they should offer « the greatest possible resistance.

« 4. By the use of high-grade steels « and by the substitution of welding for « riveting, appreciable savings in weight, « as compared with wood or riveted steel « carriages, can be effected.

« 5. The use of light metals and alloys « can also reduce the weight appreciably « and therefore offers advantages in cer- « tain structural parts under specified « conditions, in spite of their high price. « Conclusive evidence as to their beha- « viour over a long period of time is not « yet available. The Congress recom-

« mends the use of these materials to be « further investigated.

« B. — *Goods wagons.*

« 1. Metal construction has special ad- « vantages over wood for goods wagons :

« Greater strength;
« Greater safety in service;
« Longer life;
« Lower maintenance costs.

« 2. Under given climatic and oper- « ating conditions covered goods wagons, « whether of the all-steel type or of com- « posite construction, are used success- « fully.

« 3. All-steel construction for special « coal, coke, and mineral wagons is ad- « vantageous.

« 4. By substituting welding for rivet- « ing, appreciable reductions in weight « ban be effected.

« 5. The use of iron or of steels of « appropriate qualities and of copper- « bearing steel appears to be an impro- « vement in the way of protection against « corrosion. »

[656. 222.1]

Note on Train Speeds,

by Lionel WIENER,
Professor at the University of Brussels.

PART II [1].

Train speeds and services in different countries.

I. — **Generalities.** — Train speeds and tables cannot be properly appreciated from the simple enumeration of a number of tables, for these are but a single element of a complex problem — an element that results from many others and that completes them.

There are, in each country, a number of traffic currents the importance and direction of which are the outcome of national and international economics. The part played therein by train speeds is a notable one and is not restricted to fast runs or to the lines which radiate from railway centres. Even distan low-speed sections may be as important, when taking transport conditions as a whole, as the main sections where train speeds are high.

Excursion traffic, carrying its thousands to holiday resorts, is as interesting as boat trains or cross country runs that connect secondary centres or provincial towns with each other.

All these concern more specially or even exclusively the traffic of each country. But international politics have a large influence on railways and should not be disregarded when going over international railway connections.

Apart from train speeds proper, two other matters which bear on them should be taken into account. The first regards railcars which, though still in their infancy, may completely alter the methods of working certain classes of passenger and even light goods traffic.

The second is the democratisation of the *International Sleeping Car Co.*'s services. The importance, not of its continental expresses only, but also of the facilities provided in international traffic, has not been properly emphasized and has certainly not been sufficiently grasped. For many years, these amenities were only offered to first-class passengers and since the War, extended to seconds, and now to thirds as well. As these constitute the bulk of the travelling public, such services are bound to grow rapidly and to change conditions, for there is a considerable difference between providing special rolling stock for a relatively small number of high paying passengers or for a large number of low fares. Hence, the repercussion of this policy on fast railway express services may also be far reaching.

When considering such special services, those of the *Sleeping Car Co.* are

(1) Part I appeared in the *Bulletin of the Railway Congress* for October 1933, pp. 885 to 928.

mostly borne in mind and very little is known of the others. Yet those provided by the British Railway Companies, by the English and American Pullman Companies, by the *Mitropa* and certain continental railways, such as the *Swedish State Rys.* and others, deserve to be taken into equal consideration.

This shows how necessary it is to examine train speeds, not only as a whole, but more especially in each country separately and, when doing so, not to neglect the important currents of traffic. We will do so in rotation, starting with Great Britain and France, the more important countries of western Europe, and then taking Belgium, Holland, Switzerland and Italy. Next in order will come Central European countries and more especially Germany and Austria. Those of Eastern Europe can be dealt with more cursorily, but several overseas and colonial countries are of considerable interest. This is especially the case for the United States and Canada, and for several 3' 6" gauge railway systems such as those of South Africa, New Zealand, Java and Japan.

2. — **Illustrations.** — The relation of train speeds to each other and to the districts served are easily grasped when shown graphically. We will therefore give a number of cartograms showing average speeds. The highest average speed of each railway is shown and distinguished by means of various kinds of lines — always the same — growing in importance as the average speed increases in stages from six to six or even from three to three miles an hour, the best trains running at average speeds of over 38, 44, 50, 56, 59 or 62 miles per hour, which very nearly correspond to average speeds of 60, 70, 80, 90, 95 and 100 km. per hour.

To avoid repetition, this is how such train speeds are shown in the following illustrations :

Miles/hour.	LEGEND	*Km./hour.*
Over 62		Over 100
59 to 61.9		95 to 99.9
56 to 58.9		90 to 94.9
50 to 55.9		80 to 89.9
44 to 49.9		70 to 79.9
38 to 43.9		60 to 69.9
Less than 38 (Only when necessary)		Less than 60 (Only when necessary)

Fig. 7. — Representation of trains speeds.

In the cartograms, we have underlined the names of each town served by non-stop services from the capital.

It is also interesting to consider non-stop services radiating from primary or secondary railway centres. With this end in view and, for a certain number of them, we have approximately drawn the railway lines which serve them, using the kind of lines shown in figure 7, and quoted all the places served by non-stop trains.

We have also plotted distances (according to the *Y* axis) and times (according to the *X*es) on sectional paper, and accurately situated all these places. The inclination of the lines joining them to the origin shows at a glance the average speed of the fastest non-stop trains.

3. — **Tables.** — We have drawn up a considerable number of tables of train speeds because this is much clearer than lengthy explanations and also because it is the best means of giving much handy information.

In all such tables, we have used :

ordinary type, for all runs with intermediate stops;

heavy type, for non-stop runs;

italics, for runs that no longer take place but that it is useful to quote.

Railcar runs are specially designated as such.

In these tables, the run is shown in the first column. Partial runs only are also quoted but are slightly drawn back.

When it is useful to do so, we have also quoted, in parenthesis, the place where the train actually starts from or runs to.

So as to bring some kind of order into these lists, we have usually designated all runs in one direction only, such as all down from the Capital, one way only for cross country services, and from inland to the ports, for boat trains.

We always quote the fastest run (or one only of the fast runs if several of them are accomplished at the same speed). When an up train is faster than any down one, we have added the letter R (return journey) before the time of departure. When necessary, we use the letters S (Saturdays), *s* (Sundays), M (Mondays) only and have then placed them immediately after the time of departure.

In the tables of fastest or longest non-stop runs of a country or of a railway company, we only quote the longest fast run of each line and no intermediate runs, unless these be faster than the longer one. From our point of view, it is only necessary to know at what maximum average (or in some instances, overall) speed each section of line is covered. This being so, it is possible to run any number of equally fast trains according to traffic requirements, instead of a single one, or to run other trains for shorter distances at the same speeds, but this concerns railway operation and is outside the scope of this paper. Such is not the case when intermediate or shorter sections are covered at higher speed than the longer one. In the tables of interesting runs, we have, of course, quoted further runs and included the best runs from the Capital to any place reached by non-stop trains, as it is necessary to draw up our diagrams.

Exceptionally, we have quoted all very high-speed runs and all very long non-stop runs (instead of one each) along the same line, the only proviso being that they take place between different places.

We have refrained from comparisons arising out of these tables, as each reader will make his own.

Unless otherwise stated, all items concern the Summer services of 1933. When going over the runs of each country, we mention the time tables from which the data are taken.

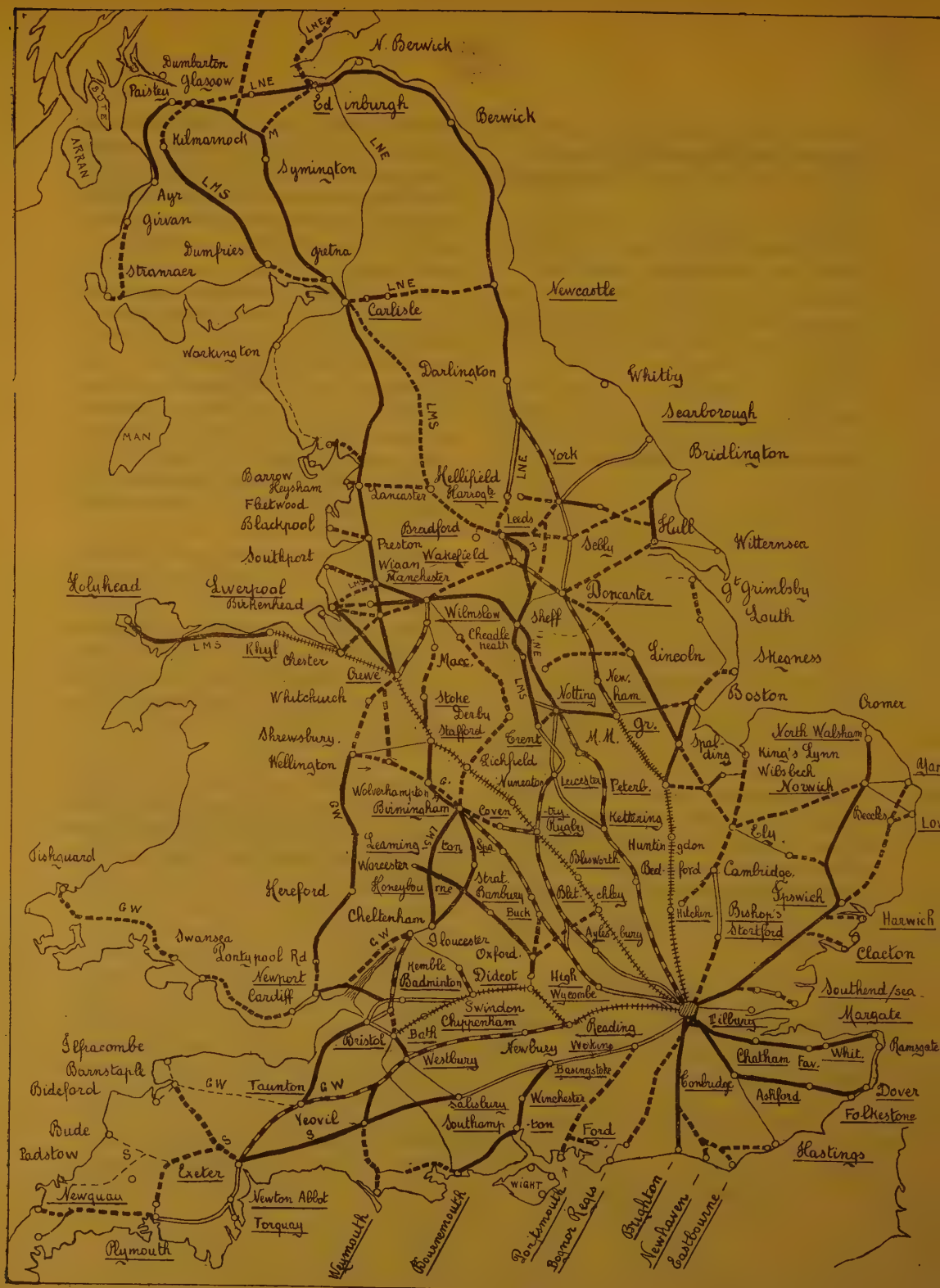

Fig. 8. — Cartogram of British train speeds (see legend p. 1028/46).
(All underlined names are towns wher non-stop runs from London end).

I. — GREAT BRITAIN.

However well known British railways may be, it is nevertheless a fact that the main principles on which they are worked are not properly grasped on the Continent, hence the results obtained are seldom fully appreciated.

Save for a few exceptions, practically all the railways are in the hands of the four large companies who inherited them from an outrageous number of autonomous undertakings, each having its own principles and methods of train working. They have now been merged so as to form the present groups, but these should not be examined without taking their past into account.

As elsewhere, the establishment of the British railway systems and train services has been influenced by geographical conditions, which have been responsible for the distribution of holiday resorts, spas and seaports. The southerly situation of London is another important factor. Highly industrialised regions such as those of South Wales, the Midlands, Newcastle and Glasgow, and conjugated centres, such as Liverpool-Manchester or Glasgow-Edinburgh are others, as are also the proximity of Ireland in the West and the Continent in the East — all factors that have their say both in the building and the working of the railways, and from which the principal currents of traffic can be deduced.

A first series of radiating lines join London with the holiday resorts and the ports. It was unnecessary to build direct radiating lines to the northern ports as they could be reached by extensions of those running from London to places half way up to the coasts, and which could be further extended.

All this is the inland point of view only. Looking at things the other way about, the steamship lines must be taken care of and boat trains comprising the most modern equipment, run from London and other centres.

Next come branch lines, many of which boast through expresses. But other causes often complicate matters. Many local districts are of such importance that special railway companies, such as the *Lancashire and Yorkshire*, the *North Staffordshire*, the *Hull and Barnsley*, the *Manchester, Sheffield and Lincolnshire* (later the *Great Central*), the *Cheshire Lines*, and others whose main West and East lines enhanced the complication of a number of railway districts, have sprung up there and turned such places as Liverpool, Manchester, Birmingham, Leeds, Nottingham and York, into important secondary railway centres.

The main lines from Scotland southwards, diverge so as to serve London on the one hand, South Wales and the West of England on the other. This happens both to the *London and North Western* and to the *Midland*'s main lines and will be dealt with under the heading of « forks ».

When these conditions of the general systems have been properly thrashed out, their train services should be looked into and then only train speeds as such will be taken into account, all these matters being dealt with in the following order :

CHAPTER VI. — The railway systems.

1. Seaports.
2. Spas, holiday and seaside resorts.
3. Alternative lines.
4. Competitive lines.
5. Joint lines.
6. Cross country lines.
7. « Forks » of the *L. M. and S. Ry.*
8. Conjugated centres.
9. Inter-Company lines.

CHAPTER VII. — Main line expresses.
1. *L. N. E.* and *L. M. S.* expresses.
2. Limited expresses of the *G. W.* and *Southern Railways.*
3. Slip carriages.
4. Newspaper trains.

CHAPTER VIII. — Sleeping, restaurant and saloon cars.
1. Pullman trains and services.
2. The International Sleeping Car Co.
3. Railway Companies' sleeping, and restaurant car services.

CHAPTER IX. — Trains other than main line expresses.
1. Summer traffic and excursion trains.
2. Urban and suburban trains.
3. Motor trains and railcars.
4. Goods trains.

CHAPTER X. — Fast and non-stop train speeds.
1. Generalities.
2. Interesting runs of each of the Railways.
3. Fast lines.
4. Short fast runs.
5. Exceptional and special runs.
6. Non-stop runs.

Conclusion.

As we are dealing with the railways, from the public's point of view, more than the Companies', we have taken times of arrival and departure from the Companies' public, and not from their service time tables, and mileages from Bradshaw.

Standardised train departure times are in force on most lines, expresses starting, whenever feasible, at the hour and a round number of minutes, all those serving the same place starting at the hour and « ten » or « fifteen » minutes and so on, instead of starting as formerly at, say, three or eight minutes past the hour. In many cases also, the runs are accomplished in the round hour, as with the Brighton services, or the round London and Birmingham two hours, and so on.

CHAPTER VI.

The Railway Systems.

VI-1. — **Ports.** — Great Britain is in the favoured position of having, besides transatlantic crossings, a large number of cross-channel services both to the Continent, Ireland and the Isle of Man. Such services have always been intimately connected with the Railway Companies who often own the boats and the harbours. This is one of the reasons they ran their own boat trains to London and, in many instances, to other towns as well, such services being maintained between :

Harwich, York (1) and Liverpool;
Weymouth and Birmingham;
Holyhead, Manchester and Liverpool;
Heysham and Leeds;
Stranraer, Glasgow and Newcastle;
Hull and Liverpool.

Table 35 gives the distances of the sea passages in nautical miles (2). We have also quoted the former Companies (3)

(1) Through carriages only, instead of through trains, now run from Harwich to York.

(2) 60 nautical miles are approximately equivalent to 70 statute miles, or more accurately, 1 nautical mile is equal to 2 023 yards, and 1 statute mile, to 1 759 only (1 852 and 1 609 metres).

(3) List of names of former and present Railway Companies which often occur in the following pages :

Cal.	Caledonian Ry.,
Ch. L.	Cheshire Lines,
G. S. W.	Glasgow and South Western Ry.,
G. C.	Great Central Ry.,
G. E.	Great Eastern Ry.,
G. N.	Great Northern Ry.,
G. N. (Ir.)	Do. (Ireland),
G. S.	Great Southern Ry.,
G. W.	Great Western Ry.,
L. Y.	Lancashire and Yorkshire Ry.,
L. B. S. C.	London, Brighton and South Coast Ry.,
L. C. D.	London, Chatham and Dover Ry.,
L. N. W.	London and North Western Ry.,
L. S. W.	London and South Western Ry.,
Met.	Metropolitan Ry.,
Mid.	Midland Ry.,
N. B.	Nord British Ry.,
N. E.	Nord Eastern Ry.,
P. W.	Portpatrick and Wigtownshire R.,
S. E.	South Eastern.

Table 35.

CROSS CHANNEL AND OTHER BOAT SERVICES.

RAILWAY COMPANY.		PORT.	Steam packet services.
	South Coast.		
G. W. R.	G. W.	Weymouth.	*Jersey* (98 naut. miles) and *Guernesey* (70).
(L. & S. W.)	S. R.	*Southampton.*	*Jersey* (130) and *Guernesey* (103).
		Do.	*Havre* (114) and *Saint-Malo* (151).
Do.	Do.	Portsmouth.	Ryde (Isle of Wight).
(L. B. & S. C.)	Do.	*Newhaven.*	*Dieppe* (64).
(S. E.)	Do.	*Folkestone.*	*Boulogne* (26) and Dunkirk (46).
(L. C. & D.)	Do.	*Dover.*	*Calais* (22) and Ostend (61).
	East Coast.		
(L. C. & D.)	Do.	Gravesend.	*Rotterdam* (164).
Do.	Do.	Queenborough.	*Flushing* (suppressed).
	L. M. S.	Tilbury.	*Dunkirk* (suppressed).
	Do.	*Goole.*	*Antwerp* (268) and *Rotterdam* (231).
(G. E.)	L. N. E.	*Harwich.*	*Zeebrugge* (82), *Antwerp* (135), *Rotterdam* (122), *Hook of Holland* (106) and *Esbjerg* (335).
	Do.	*Cleethorpes.*	*Rotterdam* (196), *Antwerp* (233).
(G. C.)	Do.	*Grimsby.*	*Zeebrugge* (in Summer) (203).
(N. E.)	Do.	*Hull.*	*Rotterdam* (208).
	L. M. S.	*Goole.*	Hamburg (405) and Antwerp (268), etc.
	West Coast services to Ireland (1).		
G. W.	G. W.	*Fishguard.*	Cork (140), Waterford (92) and *Rosslare* (54).
L. & N. W.	L. M. S.	*Holyhead.*	*Kingstown* (57), *Dublin* and *Greenore* (70).
	Do.	Liverpool.	Dublin (122), Drogheda (126) and Belfast (135).
L. & Y.	Do.	*Fleetwood.*	Belfast (115) and Douglas (in Summer).
Midland.	Do.	*Heysham.*	*Belfast* (121) and Douglas (do.) (60).
Furness.	Do.	*Barrow.*	
P. & W.	Do.	*Stranraer.*	*Larne* (35).
	Do.	Ardrossan.	Belfast (74).
	West Coast services to other islands (1).		
	Do.	Liverpool.	Douglas (70) (Isle of Man).
	Do.	Fleetwood.	Do. (56).
	Do.	Heysham.	Do. (60).
	Do.	Ardrossan.	Do. (109) and Arran.

(1) Also other ports of less importance : *Ayr, Fairlie, Gourock, Wemyss Bay, Oban, Kyle of Lochalsh.*

Table 36.

PRINCIPAL BOAT TRAINS.

Port.		Train from	Distance		Time of departure.	Time taken.	Speed		
			Miles.	Km.			Miles/h.	Km./h.	
South Coast.									
Plymouth	G.W.	Paddington	225.7	363.4	...	4.00	57.6	96.7	
Weymouth Hr.	G.W.	Do.	154 4	248.6	9.30 a. m.	3.25	44.1	71.9	Channel Islands Bt.
Do.		Birmingham	190.5	306.1	9.30 a. m.	4.43	40.4	64.9	Do.
Southampton Docks	S. R.	Waterloo	81.0	130.4	9.00 p. m.	1.55	42.3	68.1	
Do.	Do.	Cheltenham	*164.3*	*264.4*	*4.50* a. m.	*3.41*	*44.6*	*71.8*	*Ocean Bt. Exp.*
Portsmouth Hr.	S. and G.W.	Waterloo	73.8	118.8	1.50 p. m.	1.40	44.3	71.3	I. of Wight Bt. Exp
Do.	Do.	Birmingham	156.0	251.4	2.30 p. m.	4.20	58 0	36.8	Do.
Newhaven Hr.	S.	Victoria	56.5	90.9	10 05 a. m.	1.21	41.8	67.3	Continental Bt. Ex
Folkestone Hr. (1)	S.	Do.	76.0	122.3	R 1.30 p. m.	1.40	45.6	73.4	Do.
Dover Marine	S.	Do.	80.0	128.7	11.00 a. m.	1.35	50.7	81.7	Do.
Gravesend Pier	S.	Do.	27.5	44.1	*6.10* a. m.	*0.52*	*31.7*	*51.0*	Rotterdam Bt. Exp.
East Coast.									
Tilbury	L. M. S.	St. Pancras	21.5	34.6	*10.30* p. m.	*0.45*	*28.7*	*46.1*	Dunkirk Bt. train
Harwich P. Quay	L. N. E.	Liverpool St.	68.8	110.7	10.20 p. m.	1.27	47.4	76.2	
Do.		Liverpool	267.8	431.0	2.20 p. m.	7.06	39.7	60.6	
		York	211.0	339.6	3.30 p. m.	5.54	35.8	57.6	
Immingham	L. N. E.	King's Cross	172.0	276.6	10.46 a. m.	4.01	42.4	68.2	Cruise Special.
Hull	L. N. E.	Do.	197	306.9	1.30 p. m.	3.52	50.9	82.0	
	Do.	Manchest. Ln. Rd.	101	162.5	R 8.55 a. m.	2.51	35 4	56.9	
	Do.	Manchester C.	107	172.3	R 4.48 p. m.	2.56	36.4	58.5	
	Do.	Liverpool	136	219.3	1.18 p. m	3.27	39.4	63.4	
Newcastle (Tyne Commission Quay).	L. N. E.	King's Cross	276	444	1.20 p. m.	5.53	46.9	75.4	
West Coast.									
Fishguard	G.W.	Paddington	261.3	420.5	7.55 p. m.	5.47	45.2	72.7	Irish Mail.
Holyhead	L. M. S.	Euston	263 6	424.5	R12.27 noon S	5.12	50.7	81.8	Irish Mail.
Do.	Do.	Liverpool	111.8	179.9	10.45 a. m.	3.06	36.0	58.0	
Do.	Do.	Manchester	124.8	200.8	10.50 a. m.	3.01	41.4	66.6	
Birkenhead	G.W.	Paddington	210.5	338.8	R 9.05 a. m.	4.27	47.2	76.0	Belfast Bt. Exp.
Do.	Do.	Birmingham	100.0	160.9	7.15 S a. m.	2.30	44.1	71 0	Isle of Man Bt. Exp
Do.	G.W.	Paddington	210.5	338.8	1.30 a. m.	6.05	41.4	66.0	Do.
Liverpool	L. M. S.	Euston	193.5	306.6	10.40 a. m.	3.35	53.2	85.6	The Manxman.
Do.	Do.	Birmingham	88.8	142.9	R 2.00 p. m.	2.23	42.3	59.9	Isle of Man Bt. Exp
Do.	Do.	Northampton	137.0	220.5	7.15 a. m. S	2.38	52.0	83.7	Do.
Do.	Do.	Leamington Spa	125.8	202.4	5.21 a. m. S	4.32	27.5	43.9	Do.
Fleetwood	L. M. S.	Colne	48.5	78.0	8.08 a. m.	1.52	27.1	43.6	Isle of Man Bt. Exp
Do.	Do.	Manchester	50.8	81.8	1.50 p. m. S	1.30	34.0	54.6	Do.
Do.	Do.	Liverpool	48.8	77.3	1.13 p. m. S	1.53	30.1	40.2	Do.
Heysham	L. M. S.	Euston	237.5	382.2	6.10 a. m.	5.00	60.0	96.5	Belfast Bt. Exp.
Do.	Do.	St. Pancras	269.3	443.4	5.00 p. m.	6.25	42.9	69.1	Do.
Do.	Do.	Euston	237.5	382.2	6.10 a. m.	5.00	47.3	76.4	Ulster Express.
Stranraer	L. M. S.	Do.	403.8	649.8	8.00 p. m.	9.10	44.1	70.9	Larne Bt. Exp.
Do.	Do.	(Newcastle)	166.3	267.5	0.40 a. m.	5.52	28.4	45.6	
Do.	Do.	Glasgow	99.8	160.6	3.43 p. m.	2.52	34.4	55.4	The Fast Belfast.
Do.	Do.	Do.	99.8	160.6	8.00 p. m.	2.57	33.8	64.4	The Irishman.
Ardrossan	Do.	Glasgow.	32.3	52.0	4.30 p. m.	0.48	40.4	65.0	Belfast Bt. Exp.

(1) The distance from Victoria to Folkestone Jn., where the boat-trains reverse so as to descend to the Harbour, is 74.3 m (119.6 km.). The Harbour branch is 1.8 miles (3 km.) long.

(2) Suppressed since December 31st, 1926.

that served the ports and their large number explains why so many different services were run.

We have not included the short runs from Glasgow to Clyde ports, such as Craigendoran, or to Ayr, Fairlie Pier, Greenock, Gourock, Wemyss Bay, etc.

Nor have we quoted two other classes of boat trains. The first are the pre-War so called « continental expresses » which were run between King's Cross and Leeds, in connection with other boat trains, and the others are the post-War Glasgow and St. Pancras « continental services », with a through Tilbury portion connecting with the Dunkirk boat.

Boat trains influence other traffic as well, inasmuch as they usually run non-stop in several sections and they are liable to be late, when the crossing has been rough.

The *G. W.*'s Plymouth and Weymouth boat trains are handicapped by the difficult runs from the docks to the main line junction. In the latter instance, after half a mile along the quays, there is another half mile through the streets, with curves as sharp as 225 feet (68.60 m.) radius. These cannot be negociated in the ordinary way, so the gangways between the vehicles have to be disconnected, and three-link slack couplings substituted to the usual ones. For safety's sake, a man precedes the train on foot. Such conditions existed years ago in Calais and in Boulogne, and still do in Syracuse and other American cities, but they are quite unexpected in England.

The *S. Ry*'s London, Folkestone and Dover services require some comment owing to the multiplicity of routes they may follow. Thus we have shown (fig. 9), principal gradients of a 78-mile (125.5 km.) London and Dover line, whereas the tables quote 80-mile (128.7 km.) runs for the boat trains. Both distances are accurate, the longitudinal section applying to the shortest (*S. E.*) Charing Cross and Dover line and the tables to a route sometimes followed by the boat trains.

No other British Railway Co. owns as many alternative routes, some of which belong to the two formerly competitive *S. E.* and *L. C. D.* Railways, other routes being provided through the building of four track links between Chislehurst and Orpington (*S. E.*), Bickley and St. Mary Cray (*L. C. D.*).

The original *S. E.* Charing Cross, Tonbridge and Ashford line was 75.7 miles long as far as Dover Town and 76.9 to Dover Marine (121.8 and 123.8 km.), the *Chatham*'s route being just a little longer : 78.4 miles from Victoria to Dover and 78.9, from Holborn Viaduct (126.1 and 127 km.). It is now only used as an emergency route, the boat trains from Victoria to Dover being diverted to the *S. E.*'s main line between Bickley ond Orpington, which brings the total distance up to 78 miles (125.5 km.), as shown fig. 9. But occasionally, other routes such are used (see Appendix, Chapter IX*bis*).

All these lines cross the North and South Downs, which involved some long banks and a good deal of tunneling, and the line is considered a hard one for the locomotives, but as recently as 1930, the fastest trains ran from Charing Cross to Dover in 80 minutes and to Folkestone in 85. They have been decelerated since, but in spite of this, the London-Folkestone and London-Dover boat trains are the more important, as two cross channel services start from each of these ports. A comparison between the Dover and Brussels boat trains is therefore interesting, as there is not much difference in the length of the railway runs at either end.

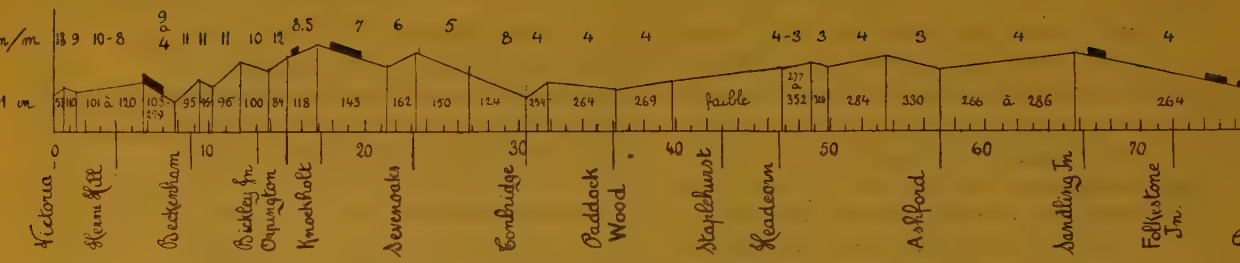

Fig. 9. — Gradients of the London and Dover line.

TABLE 37.

LONDON-DOVER AND BRUSSELS-OSTEND LINES.

LINE.	Distance		Maximum gradients.	
	Miles.	Km.	1 in	mm./m.
London (Victoria)-Dover (Marine). . . .	80.0	128.7	57	175
Do. (Char. Cross)-Dover (Priory). . .	77.3	124.4	95	106
Brussels (Nord)-Ostend (Q.) Old line. . .	74.8	120.4	175	57
Do. Do. New line. . .	72.9	117.3	175	57
Brussels (Midi) Do. New line. . .	71.4	114.9	200	50

The gradients of the Dover line and location of tunnels (1) are shown in figure 9. It is in a favoured position as regards curves and has between Tonbridge Jn. and Ashford, the longest stretch of dead straight line to be found in the Country (2).

Besides the continental boat trains, there is a complete service of fast trains to Folkestone, Dover and beyond, giving the usual seaside resort facilities.

Detailed information regarding the Brussels and Ostend runs will be found

(1) The Sevenoaks tunnel is 3 451 yards (3 156 m.) long; Abbot's Cliff tunnel is 1 933 yards (1 807 m.) and Shakespeare tunnel 1 392 yards (1 273 m.).

(2) There is a slight deviation at Stapleton in the otherwise straight 24-mile (38.6 km.) stretch from Tonbridge Jn. to Ashford; but it is dead straight from Tonbridge Jn. to Staplehurst, a distance of 10.5 miles (16.9 km.).

On the *Brighton Ry.* the longest straight section, 8 miles (12.9 km.) long, occurs between Salford and Balcombe tunnel.

Many of the *L. & N. E.*' s lines of the York District have long straight stretches, such as those between Selby and Hull : 18 miles (29 km.), Boston and Burgh le Marsh : 16 miles (25.7 km.), York and Raskelf : 10 miles (16.1 km.).

The *L. M. S.*'s longest straight stretch occurs between Hooton and Helsbey : 7.8 miles (12.6 km.).

On the *Great Western*, there are two not able straight sections, both 5.3 miles (8.5 km.) long, from Neilsea to Worle and from Mangor, near Newport, to Lliswerry.

The longest straight stretch in Scotland is situated on the Dundee and Arbroath Jt. line, and is but 4.8 miles (7.7 km.) long.

in the Chapter dealing with the Belgian services.

The Tilbury and Dunkirk service was essentially a competitive one. It was started by the *L. M. S. Ry.* in 1926 with excellent continental connections to Paris, Alsace-Lorraine and Switzerland and English connections through St. Pancras to Leeds and Glasgow. It was maintained until April 1932, when the *L. M. S.* gave it up and the *Southern* Ry. ran the English portion of the service via Folkestone to Victoria.

The Harwich continental services to Zeebrugge, Antwerp, Rotterdam, Hook of Holland and Esbjerg, now start from Parkeston Quay. Boat trains run from Harwich to Liverpool Street (1) and over the former *G. N.* and *G. E. Joint Rys.*, to the Midlands and Lancashire towns. They formerly ran to York (2), but have been diverted to Liverpool via the *Cheshire Lines* with through carriages to Birmingham.

Besides the London and the Provincial trains, local trains are run in some districts, such as those from Colne to Fleetwood, and pre-War Brighton and Newhaven and local Dover services.

In other cases, such as the Portsmouth and Ryde or the Clyde services, there is no essential difference between boat or rail suburban services.

There are hourly Saturday services from Waterloo to Portsmouth in connection with the Isle of Wight *Southern Ry.* boats (3) to Ryde and a number of boat trains from Glasgow to the Clyde Ports. Both the former *Caledonian* and *North British* Railways ran fast competing trains from Glasgow, which were very similar to those to be found on most suburban lines. On the left bank, they served such places as Greenock, Gourock and Wemyss Bay where both Companies' boats called. As both lines served several of these places, a single train would connect with more than one boat. To give better and faster service still, some of them left and indeed, still leave Glasgow at the last possible moment and take no luggage so that embarkation be expedited. The boats of the rival Companies then raced on to Dunoon, and other places on the opposite bank.

TABLE 38.

TRAINS BETWEEN GLASGOW AND THE PRINCIPAL CLYDE PORTS.

RUN.	Distance		Time spent.	Speed		
	Miles	Km.		Miles/h.	Km./h.	
Glasgow C.-Greenock	23.0	37.0	0.32	43.5	70.0	
Do. -Gourock	26.3	42 3	0.38	45.4	73.1	
Do. -Wemyss	31.0	49.9	0.48	38.7	62.3	
Glasgow L. L.-Balloch Pier . . .	19.5	31.4	0.40	29.2	47.1	1 stop.
Do. -Paisley-Greenock Pier	25.3	40.7	0.40	25.8	41.5	1 stop S.
Glasgow-Ardrossan (1)	32.3	52.0	0.48	40.4	65.0	
Do. -Fairlie Pier	40.8	65.7	0.52	47.2	75.9	2 stops.

(1) Belfast Boat Express.

(1) The « Flushing and Antwerp Continental » now carries passengers for both boat services. Since the consolidation, this train has been slackened by five minutes.

(2) They covered the 51 miles (82.1 km.) from Peterboro' to Rugby, in 66 minutes nonstop, i. e. at an average speed of 46.3 miles (74.5 km.) an hour.

(3) Formerly, *L. B. S. C.* and *L. S. W.* joint service.

Boat trains, such as « The Hebridean » and « The Lewisman » are run on much slower schedules, between Inverness and the Kyle of Lochalsh.

Transatlantic services. — There are far fewer of these, than of cross Channel services and they present an additional complication in that whilst several schedules must be provided one of them only is used according to the time the liners berth.

a) *Great Western Ry.* — Whereas in 1921, 354 liners called at Plymouth, there were 674 in 1932, the number of passengers landed being 13 170 and 38 462 respectively.

The *G. W. Ry.* tried running Pullman cars in its day boat expresses (in 1929) but soon gave them up and now runs its own « de luxe » saloons for which an extra 10-sh. fare is charged.

The trains proceed from Plymouth to Paddington via Westbury or via Bristol and Badminton, according to the arrival of the boats. When running non-stop via Westbury, they take 4 hours, 4 h. 10 m. or 4 h. 18 m., according to their weight being : 175 tons (or under), 288 tons, or over 288 tons. If they are hauled by « Castle » locomotives, the limit weights are 200 and 305 tons; if by « Kings », 250 and 350 tons. When a stop at Exeter *or* Taunton is inserted, an extra five-minute allowance is made.

Over the longer Bristol and Badminton route, the trains take 4 h. 29 m. (or 4 h. 38 m. or 4 h. 49 m.) with one stop either at Bristol or at Westbury, and five minutes more with two stops, at Exeter and Bristol. We have quoted these figures kindly supplied by the *G. W.* as an instance showing a few of the many items that must be taken into account when timing Ocean specials.

b) The *Southern Ry.* used to run Ocean specials from Devonport to Waterloo, but these have been given up and the sleepers sold to the *G. W. Ry.*

The Company's present Ocean port is Southampton where Ocean specials are run from independently of the Channel Islands boat expresses. They take 1 h. 45 m. from the Docks to Waterloo, and it is no easy matter to insert them between the usual heavy daily traffic. To quote an exceptional instance : as luck would have it, on July 30th, 1932, no fewer than fifteen liners arrived the same day and these included such boats as the « Berengaria », the « Leviathan » and the « Olympic », out of which 4 313 passengers landed with their luggage. This called for 18 specials, for which 155 coaches, 27 Pullmans and 26 luggage and mail vans were required (1).

VI-2. — **Seaside and other resorts.** — There are a number of these resorts along the entire coast, some far famed, others locally known only. At first, these latter are only connected with the nearest town, and by branch line trains only, until their attractions are better known and through trains are run from places further away.

In other instances, a number of these resorts are each linked up by short branches, with more important lines run-

(1) There were three « Olympic » specials, two each for the « Homeric », the « Aquitania » and the « Berengeria », one for the « Empress of Britain », the « Pennland », the « Ormonde », etc.

As a rule, each train carried from 300 to 400 passengers in 11 to 13 carriages, which included 2 Pullmans and 1 or 2 vans. The maximum was 528 passengers and 14 cars in the « Olympic » and « Ormonde » trains and the minimum, 50 passengers only in a third three-car train which ran from Walton.

ning more or less parallel with the coast. Thus the south coastal 151-mile (241 km.) line from Ramsgate to Brighton and Weymouth, after serving Dover and Folkestone, is joined by short branches with a number of seaside resorts :

Hythe, Dungeness; Eastbourne, Newhaven, Littlehampton, Bognor Regis and, further on, Lymington, Swanage and Bridport.

Other lines radiate from London to these seaside resorts and give direct connection with :

Southhampton — Fareham — Havant;
Bognor Regis — Brighton — Newhaven — Eastbourne;
Hastings — Folkestone and Dover;
Ramsgate — Margate,

and some of them divide into other radiating lines running to places in between. They reach the coast at an average distance of 15 miles (24 km.) from each other.

It is curious that, in spite of this, some of these places nearest to London, are not sufficiently important to justify the running of London non-stop trains. This is the case for Bognor Regis and Littlehampton, though there exists a direct line from London, for West Worthing and Hove, which one must travel through Brighton to get to, and for several others such as Eastbourne, Hastings, Dungeness and Hythe.

Further west, similar branches connect the Exeter line with such places as

Lyme Regis, Seaton, Sidmouth, Exmouth and Barmouth.

On the other hand, fast through services are run from London to the Cornwall resorts, though they are further away and the branches off the main line are longer.

TABLE 39.

SOME SEASIDE BRANCHES.

MAIN LINE JUNCTION.	Distance from London.		Branch terminus.	Length of branch.	
	Miles	Km.		Miles	Km.
East Coast.					
York	188.2	302.6	Scarborough	41.8	64.4
Burnmouth	341.1	547.3	Eyemouth	3.0	4.8
Drem	375.5	604.2	North Berwick	4.8	7.7
West Coast.					
Crewe	158	254.3	Holyhead	105.8	170.2
Wigan	194	312.2	Southport	17.0	27.4
Preston	209	336.4	Blackpool	21.0	33.8
Lancaster	230	370.0	Heysham	7.5	12.1
Gretna	307.5	495.9	Stranraer	98.5	158.5

Similar considerations apply to the Liverpool Street and Yarmouth line and even to the East and West Coast Routes, the branches of which vary very much in length.

TABLE 40.

TRAINS FROM LONDON TO SEASIDE AND HEALTH RESORTS.

HEALTH OR PLEASURE RESORT.	Railway Company.	Distance		Time of departure.	Time spent.	Speed		
		Miles.	Km.			Miles/h.	Km/h.	
Margate	S. R.	74.0	119.1	3.15 p. m.	1.35	48.9	79.3	
Folkestone	—	69.9	112.3	7 15 p. m.	1.16	54.6	87.9	
Brighton	—	50.8	81.8	11.00 a. m.	1.00	50.8	81.8	The Southern Belle.
Bournemouth	—	108.0	173.8	4.30 p. m.	2.00	54.0	86.9	Bournemouth Ltd.
Exmouth.	—	182.3	293.4	11.45 a.m. S	3.49	47.2	76.1	
Ilfracombe	—	226.4	364.7	10.35 a. m.	5.13	43.6	70.2	Atlantic Coast Express.
Torquay	G. W.	199.7	322.4	12 00 noon S	3.35	56.2	90.4	Torquay Express
Falmouth	—	291.0	468.3	10.30 a. m.	6.15	49.7	74.6	Cornish Riviera Ltd.
Minehead.	—	167.5	269.3	12.05 noon S	3.28 Fr.	47.4	76.4	
Weston-super-Mare	—	137.5	221.3	11.15 a. m.	2.30	55.0	88.5	
Cheltenham Spa.	Do.	121.5	195.5	R 8.00 a. m.	2.30	48.6	78.2	
Malvern	—	128.5	206.8	4.45 p. m.	2.49	45.7	73.5	
Bath	—	106.9	172.0	11.15 a. m.	1.44	61.7	99.3	
Leamington Spa.	—	87.3	140.5	11.10 a. m.	1.30	58.2	93.6	
Barmouth	Do.	259.3	385.1	10.20 a. m.	6.13	38.5	62.0	Cambrian Coast Express
Aberystwith	—	234.3	377.0	Do	5.35	41.7	67.2	Do.
Neyland	—	260.8	419 8	1.55 p. m. S	6.45	38.6	62 2	
Colwyn Bay	L. M. S.	219.8	353.7	R12.06 noon S	4.54	45.0	72.4	
Llandudno	—	227.1	365.5	11.15 a. m.	4.45	47.8	77.0	The Welshman.
Bangor	—	239.1	384.7	Do.	4.45	50.0	81.0	Do.
Southport	Do.	211.5	339.8	6.10 p. m.	4.01	52.6	84.6	
Blackpool	—	226.8	365.0	12.00 noon	5.08	44.1	71.1	
Barrow	—	254.5	409.5	Do	5.40	44.9	72.3	
Windermere	—	264.8	495.6	Do.	5.50	52.8	85.0	
Oban	Do.	503.8	810.8	7.30 p. m.	13.25	37.6	60.5	
Clacton-on-Sea	L. N. E.	70.8	113.9	9.55 a. m. S	1.30	47 2	75.8	The Eastern Belle Pullma
Lowestoft	—	117.8	189.6	12.56 noon	2.40	44.2	71.4	
Cromer	—	139.0	223.7	12.25 noon	2.57	47.2	75.9	1 stop : N. Walsham.
Harrogate	Do.	202.8	326.4	10.00 a. m.	4.00	50.4	81.6	Harrogate Sunday Pullma
Scarborough.	—	230.0	370.0	11.53 a. m.	4.00	57.5	92.5	Scarborough Flier.
Fort William	—	559.8	903.9	7.25 a. m.	13.53	33.7	54.2	
Ventnor	I. of Wight	103.0	165.7	11.50 a. m.	3.33	29.2	46.9	Via Portsmouth.
Douglas	I. of Man	275.1	442.7	10.40 a. m.	8.20	32.9	53.1	Via Liverpool.

Another distinctive feature of British seaside services is that instead of having through carriages only, the best known are litterally flooded with through week-end restaurant-car trains from London and a number of other places.

Saturday trains to Llandudno, in North Wales, arrive from most Lancashire and Midlands towns such as

Liverpool, Birkenhead, Manchester, Warrington Holyhead, Bury, Bolton, Colne;
Huddersfield;
Birmingham, Stoke-on-Trent :
Sheffield, Bradford, Nottingham, Leeds, etc.

Blackpool, to the North of Manchester, has direct express services to and from

Morecambe Bay;
Manchester, Liverpool, Warrington, Wigan, Stockport;
Leamington Spa, Birmingham;
Cross Lane, Crewe, Stoke-on-Trent, Willesden Jn., London, etc.

And Brighton, where as many as 400 trains arrive and leave in the course of the day, has double the Blackpool traffic. As many as 40 trains have been dealt with in an hour, on Bank Holiday.. Until 1931, some 14 000 000 passengers went there annually, including 5 000 000 in the short railway Summer and some 1 500 000 tickets used to be sold in Brighton annually.

Paignton (*G. W.*) has through services to Birmingham, Liverpool, Manchester, Swanage, Bradford, etc.

And conversely, a place such as Manchester, runs through expresses to a number of summer resorts.

A FEW MANCHESTER SUMMER RESORT SERVICES.	Distance. Miles.	Km.	Time of departure.	Time spent.	Speed. Miles/h.	Km./h.	Stops.
Manchester Vict.-Stockport (St. Luke's .	32.5	52.3	5.22 p. m.	0.42	46.4	74.6	
Do. -Blackpool	50.8	81.8	5.07 p. m.	1.03	48.0	77.2	
Do. -Lytham	43.5	70.0	5.14 p. m.	1.00	43.5	70.0	
Manchester Exch.-Llandudno . . .	86.8	138.5	4.30 p. m.	2.08	40.2	64.7	6
Do. -Windermere . . .	82.3	132.5	5.05 p. m.	1 07	38.1	61.4	3
Do. -Buxton	25.3	40.7	5.38 p. m.	0.47	32.2	51.8	1

Others run to

Colwyn Bay, Holyhead, Bangor;
Aberystwith, Pwllelhi and Swansea;
Paignton and Penzance, on the *G. W.;*
Portsmouth, Bournemouth, Brighton, Hastings, Eastbourne and Ramsgate, on the *Southern.*

And there are, of course, the usual expresses to Aberdeen, Glasgow, Newcastle, etc.

VI-3. — **Alternative routes.** — British industrial districts contain a larger number of important towns than do other countries and a few of them only are situated on the main lines; so alternative routes are provided to serve some of the others and this is the case for each of the three Anglo-Scottish Companies.

TABLE 41.

ALTERNATIVE ROUTES OF THE LONDON AND SCOTLAND AND LONDON AND MANCHESTER LINES.

MAIN LINE FROM LONDON TO	Railway Company.	Alternative routes between	Via	Distance Miles.	Distance Km.
Scotland	L. & N. E. Ry.	Doncaster, Northallerton	Church F.-Harrogate	76.0	122.3
			Wakefield Do.	70.0	112.7
		Do.	Leeds. Do. (1)	73.0	117.5
		Do.	York	62.0	99.8
	Form. Midland Ry.	Derby, Trent, Kettering	Leicester	56.5	90.9
		Do.	Nottingham	67.5	108.6
	Form. L. & N.W.Ry.	Roade, Rugby	Blisworth	22.5	36.2
		Do.	Northampton	25 0	40.2
	Form. L.&N.W.Ry.	Rugby, Stafford.	Lichfield	51 3	82.6
		Do.	Birmingham	48 8	78.5
Manchester	L. M. & S. Ry.	Stafford, Manchester	Crewe.	66.0	106.2
		Do.	Stoke-on-Trent	53.5	86.1

Some of the main line expresses use these deviations even when they are longer. Thus Stoke-on-Trent is served by the down « Mancunian » and by the up « Lancastrian » and, on the *Midland* the « Thames and Forth Express » travels via Nottingham and the « Thames and Clyde », via Leicester.

The same occurs on the *L. and N. E.* whose « Queen of Scots » and « West Riding » Pullman trains travel through Bradford, whilst the « Flying Scotsman » runs straight through, via York.

TABLE 42.

A FEW ALTERNATIVE SOUTHERN RAILWAY LINES.

RUN.	Via	Former Company.	Distance Miles.	Distance Km.	Time of departure.	Time spent.
Victoria-Margate	Chatham	L. C. D.	74.0	119.0	5.00 p. m. S	1.39
Cannon St.- Do.	Ashford	S. E.	77.5	124.4	5.04 p. m.	1.33
Victoria-Ramsgate	Chatham	L. C. D.	79.5	127.9	5.00 p. m. S	2.00
Charing Cross.-Do.	Ashford	S. E.	86.0	138.4	4.15 p. m.	2.22
Victoria-Dover	Chatham	L. C. D.	77.3	124.4	2.05 p. m.	2.17
Do.	Tonbridge.	S. E.	80.4	128.7	11.00 a. m.	1.35
Cannon-St.-Hastings	Tonbridge	S. E.	61.0	98.2	5.06 p. m.	1.35
Victoria - Do.	Lewes	L.B.S.C.	76.3	122.8		
L. Bridge-Portsmouth	Horsham	L.B.S.C.	86.5	139.2	1.24 p. m.	2.38
Waterloo - Do.	Guilford	L. & S.W.	73.8	118.8	1.50 p. m.	1.40

Since the grouping, formerly independent lines have come into the same hands and much railway competition has been done away with. Thus the former *Midland* St. Pancras, Carlisle and Glasgow (via Dumfries) main line, is now but an alternative *L. M. S.* route. Many a provincial town thus has the choice of two or more lines which used to belong to different companies.

The same thing occurs in the *L. N. E.* zone, owing to the amalgamation of the *G. C.*, *G. N.* and *G. E.* systems, and also applies to the *Southern* which now comprises the lines of the former *L. C. and D.* and *S. E.* on the one hand, of the *L. B. and S. C.* and its neighbours, on the other.

Since the grouping, the *Chatham* boat trains have been withdrawn and several of the *Midland* expresses, transferred to the West Coast. But when towns have long enjoyed privileges due to former competition, it is unwise to curtail them.

The *G. W.*'s case is a different one (fig. 10). The old 7-foot gauge main line was built from Paddington to Plymouth, a distance of 246.8 miles (397 km.), through Reading, Swindon, Bristol and Taunton, and further West still, to Penzance. Later on, a 106.9-mile (168 km.) cut-off was built from Reading to Taunton, via Castle Cary.

The greater number of West of England trains run via Devizes and Castle Cary, the Bristol trains following the older line, and some of them running via Badminton, along the first portion of the South Wales line. Distances from Paddington to Bristol by the three routes are :

	Miles.	Km.
Via Reading and Swindon. .	118.3	191.2
Via Badminton.	117.6	189.2
Via Devizes	121.3	195.6

VI-4. — **Competitive lines.** — These owe their existence to the formerly large number of Companies who built railways from London to the Provinces and between Provincial towns. In spite of many a drawback, such competition has done much to improve railway services and to hasten the development of the districts concerned; hence most competitive lines are high-speed lines. But since the grouping, several of them have come into the same hands and lost their aggressive character.

a) Anglo-Scottish services (fig. 9*a*). — No mention of competitive lines would be complete without reference to the most famous of them all, the East and West Coast Anglo-Scottish services, and in some measure, of the *Midland*'s as well. As the latter's line is, however, longer and harder, the Company mostly endeavoured to retain on its own metals the traffic to and from the places it served on the way.

There is an essential difference between the two coastal routes. Whereas beyond Edinburgh, the East Coast runs westward to Glasgow and northward to Aberdeen and Inverness, the West Coast has four separate lines or branches to the four same places and is obliged to run four sections where the East Coast needs but two.

The *L. M. S.* now has two alternative routes between London and Carlisle (former *L. and N. W.* and *Midland*), two on to Glasgow (*Caledonian* and *G. S. W.*) and two to Edinburgh, which the *Midland* reaches over the *North British*'s « Waverley Route », now part of the *L. N. E.* system. Between Carlisle and Glasgow, Shap (915 feet = 280 m.) and Beattock (1 015 feet = 310 m.) summits are climbed.

The East Coast Route is exception-

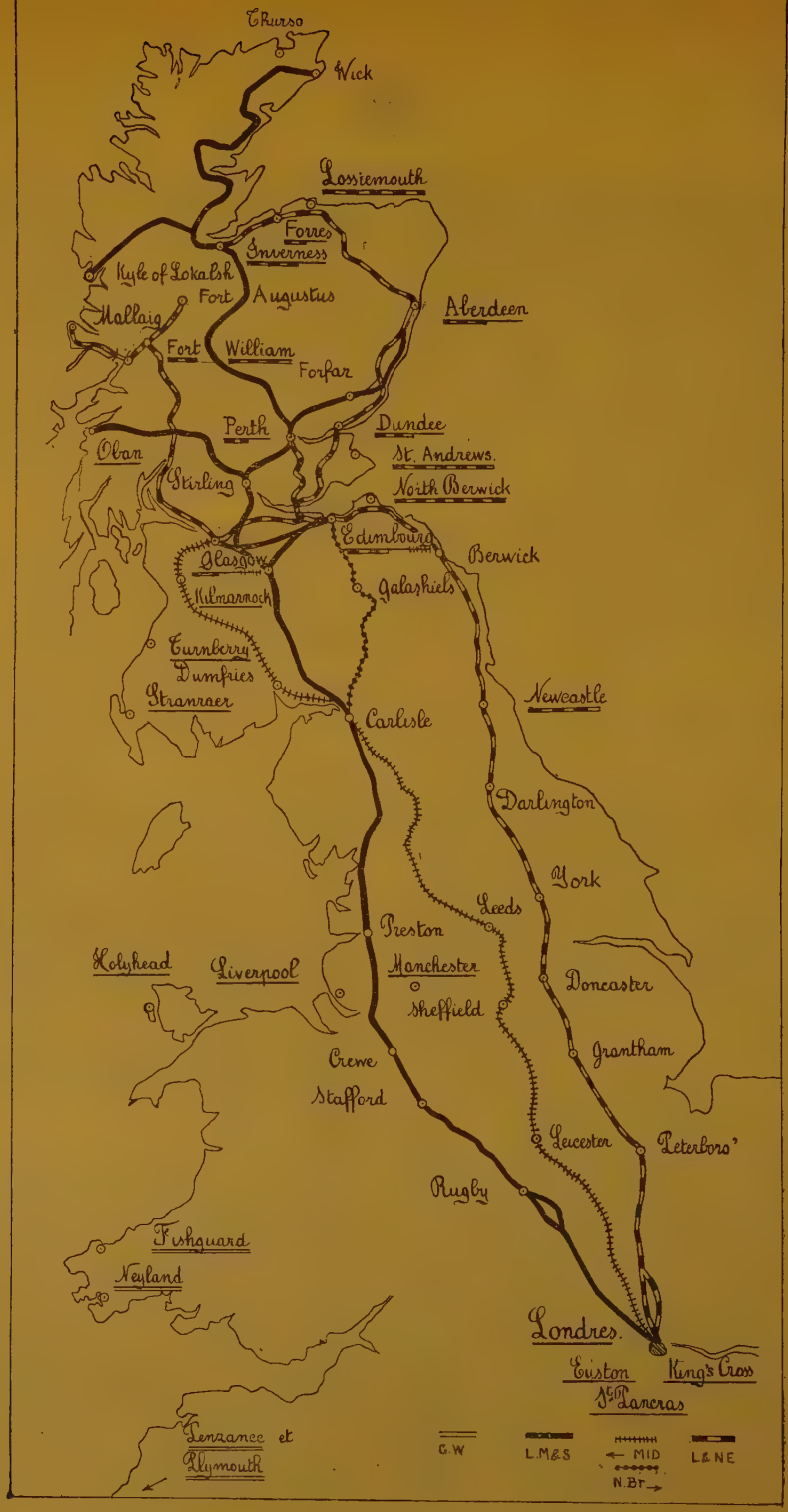

Fig. 9*a*. — Competitive routes from London to Scotland.

(See legend on page $\frac{1028}{46}$.)

Sleeping car services. — The towns where they run to are underlined differently, according to the owning railway.

ally easy, with no gradients steeper than 1 in 200 (5 mm. per m.), save for a mile or so out of London, as much into Edinburgh and also between Durham and Birtley. It has been straightened out since its inception, for it followed a roundabout course.

TABLE 43.

SECTION OF MAIN LINE CUT-OFF.	Former distance.		Present distance.	
	Miles.	Km.	Miles.	Km.
1852. Peterborough-Boston-Retford	81.8	131.7	62.3	100.3
1871. Doncaster-Church Fenton-York	35.8	57.6	32.0	51.5
1872. Durham-Penshaw-Newcastle	18.8	30.3	15.0	24.1
Edinburgh-Perth-Aberdeen	143.0	225 8	114.5	184.2
1850 and 1933. London-Edinburgh	420.0	675.9	392 7	631.9
Do. London-Aberdeen	575.0	918.1	523.5	842.4

The journey to Glasgow or to Perth was never a difficult one, but travelling to Aberdeen used, at first, to have many a drawback. In 1876, Aberdeen was reached between 3 and 4 a. m. and only if the four transhipments from train to the Forth and Tay ferries and vice versa, could be accomplished in decent weather. The crossing was often so choppy that passengers spent the night on the way, hoping for better weather next day.

TABLE 44.

FAST ANGLO-SCOTTISH SERVICES BY COMPETING ROUTES. (See fig. 9*a*.)

RUN.	Company.	Distance		Time spent.	Speed		—
		Miles.	Km.		Miles/h.	Km./h.	
London to Carlisle	L. M. S.	299.0	481.2	5.34	53.7	86.4	Royal Scot.
	Midland.	310.5	499.7	6 15	49.7	80.0	Thames Clyde Exp.
London to Glasgow	L. M. S.	401.5	646.1	7.40	51.7	83.2	Royal Scot.
	Midland.	426.0	685.9	8.50	47.6	76.6	Thames Forth Exp.
	L. N. E	440.3	708.6	8.53	49.6	79.9	Flying Scotsman.
	N.W.+G.S.W.	415.0	662.2	9.01*s*	46.0	74.0	Night Scot.
London to Edimburgh	L. M. S.	400.0	643.7	7.40	51.7	84.0	Royal Scot.
	Midland.	408.8	657.9	8.52	46.1	74.1	Thames Forth Exp.
	L. N. E.	392.7	631.9	7.30	52.4	84.3	Flying Scotsman.
London to Perth	L. M. S.	450.0	724.2	9.25	47.6	76 6	
	L N.E.	440.8	709.4	9.16	47.6	76.6	
London to Dundee	L. M. S	471.0	756.5	10.15	45.8	73.7	
	L. N. E.	452.3	727.9	R 9.25	47.4	76.2	Flying Scotsman.
London to Aberdeen	L. M. S.	540 0	869.0	11.50	45.3	72.9	
	L. N. E.	523.5	842.4	11.30	45.5	73.2	Flying Scotsman.
London to Inverness	L. M. S.	568.0	913.9	13.25	42.3	68.0	
	L. N. E.	558.8	899.3	13.20	41.9	67.4	

Fig. 10. — *Great Western Ry.* and *Southern Ry.* competitive routes from London to Weymouth, Exeter, Plymouth and Barnstaple.
G. W. shown in heavy lines and *S. Ry.* in light lines.
Alternative *G. W.* lines are also shown.

It will be remembered that the first Tay bridge and a train with it was carried away by the wind in December 1879, barely a few months after it had been opened to traffic (1). The new 10 780-foot (3 286 m.) bridge was opened to traffic in 1888 and the 8 298-foot (2 529 m.) Forth bridge, in March 1890 (2), the East Coast thus securing the shorter route to Aberdeen, Perth and Inverness.

As there are a number of important towns to the West of Doncaster and York and at no great distance from the main line, an alternative and barely longer route (only 11 miles = 17.7 km. more) though a harder one, is used between Doncaster and Northallerton, the Harrogate through trains running via Doncaster and Church Fenton, and the Leeds trains, either direct from Doncaster or through Wakefield, including such important trains as the « Queen of Scots » and the « West Riding Pullman ».

b) The GREAT WESTERN AND THE SOUTHERN Western main lines run from London to Exeter, where they cross each other, and meet again at Plymouth. Besides this, both Companies have Barnstaple branches.

They are actively competitive as far as Exeter, the *Great Western*-line being the easier. Its Barnstaple branch, which penetrates into *Southern* territory, is shorter than the latter's.

Both main lines have steeper gradients than one would expect to find on them. The *Southern* has the Honiton bank, be-

(1) 73 lives were lost.

(2) The cantilever portion is 5 349 1/2 feet (1 630 m.) long; the two approach viaducts are 1 983 feet and 965 feet (604 and 294 m.) long.

tween Waterloo and Exeter with a long 1 in 70 (14 mm. per m.) gradient and there is a short 1 in 37 (27 mm. per m.) bank at Queen Street. On the other hand, the Barnstaple line is an easy one with no gradients more severe than 1 in 110 (9 mm. per m.).

The *G. W.* main line (fig. 11) is easy as far as Newton Abbot but is harder beyond.

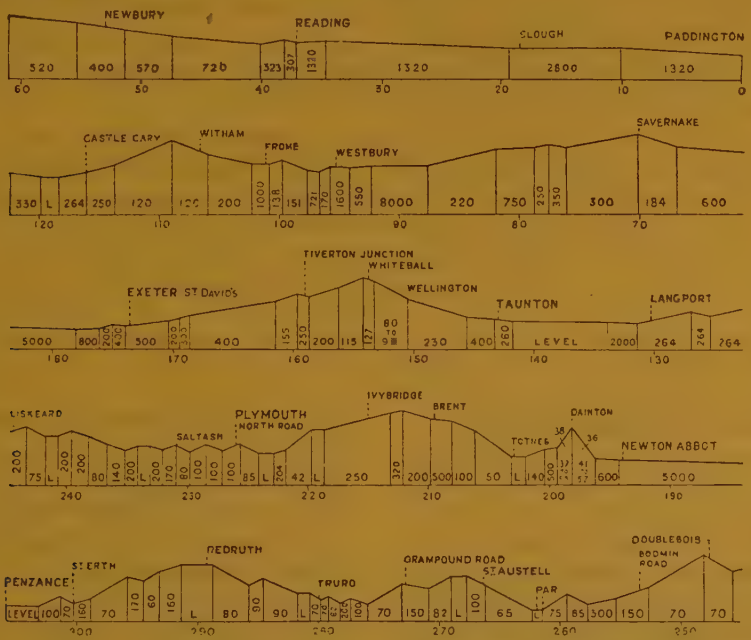

Fig. 11. — Gradients of the Paddington and Penzance main line (*).

Many years ago, the *G. W.* started building cut-offs so as to shorten its lines and out-distance its competitor. This began in 1901, when the Patney Westbury cut-off, which avoided passing through Chippenham, shortened the distance to Weymouth by 14.5 miles (23.3 km.) which put the *L. S. W.* out of the running.

At this period, the *G. W.*'s best time to Exeter was 3 h. 25 m. for 194 miles (312.2 km.), whereas the *L. S. W.* led by 10 minutes over its 22-mile (35.4 km.) shorter route.

The *G. W.* further improved this timing and in 1904, ran its new « Cornish Riviera Ltd. » non-stop over the 245 3/4 miles of its Bristol route (395.4 km.) to North Road, Plymouth, in 4 h. 27 m. But in 1905, it opened the Castle Cary Cogload cut-off and transfered the « Cornish Riviera » to the 20-mile (32 km.) shorter Westbury route which enabled it to gain 20 minutes on its previous timing. Here again, as with the Weymouth traffic, the *L. S. W.* was unable to compete further and ceased to strive for the through traffic to places beyond Exeter. (See Appendix, Chapter IX*bis*.)

(*) Reproduced from Great Western King of Locomotives.

TABLE 45.

COMPETITIVE SERVICES BETWEEN LONDON AND EXETER, PLYMOUTH AND BARNSTAPLE. (See fig. 10

FROM LONDON	To	Via	Distance		Time of departure	Time spent.	Speed		
			Miles	Km.			Miles/h.	Km./h.	
Paddington . . .	Weymouth	Reading	154.5	248.6	7.30 p.m.	3 10	48.8	78 5	
Waterloo. . . .	Do.	Basingstoke	142.6	229.5	R 7.32 a.m.	3.08	45.6	73.4	Bournemouth Ltd
Paddington . . .	Exeter	Devizes	173.3	279.6	12.00 noon	2.50	61.3	98.7	Torbay Express.
Waterloo. . . .	Do.	Salisbury	171.8	276.5	11.00 a.m.	3.14	53.1	85.4	Atlantic Coast Ex
Paddington . . .	Plymouth	Devizes	225.7	363.4	10.30 a.m.	3.57	57.6	92.7	Cornish Riviera Ex
Waterloo. . . .	Do. (1)	Salisbury	230.7	371.2	11.00 a.m.	5.14	44.1	80.0	Atlantic Coast Exp
Paddington . . .	Barnstaple	Taunton	188.8	303.9	12.05 noon	4.10	39.1	62.9	
Waterloo. . . .	Do.	Exeter	210.3	338 4	11.00 a.m.	4.39	48.7	78.3	Atlantic Coast Exp

(1) In 1930, a « newspaper express » left Waterloo at 1.30 a. m. and although it was made up of 13 to 15 vehicles, covered the distance in 4 h. 50 m. It has now been decelerated.

Non-stop runs take place from

Paddington to Weymouth, all the year round;
Waterloo to Exeter, in Winter;
Paddington to Plymouth, during the Summer season.

But apart from passenger traffic, the mails are worth fighting for and it was after strenuous competition that the contracts were won and retained by the West Coast in spite of the East Coast's endeavours, by the *South Eastern Ry.*, though the *Chatham Co.* ran the Dover and Calais mail packet service and, in this instance, by the *G. W.* instead of the *L. S. W.* This was the primary cause for racing the American mails from Plymouth to London and, incidentally, enabling the 4-4-0 locomotive « City of Truro » (now in the York Museum), to reach the highest properly authenticated train speed of over 100 miles an hour. (See Chapter X-5.)

The Channel Islands traffic has been pooled, the day Waterloo and Southampton service being taken care of by the *Southern Ry.* and the night Paddington and Weymouth service, by the *G. W.* Unlike the former *L.B.S.C.* and *L.S.W.* Portsmouth and Ryde steamers, those of the Weymouth and Southampton lines are not jointly owned.

c) CLYDE BANKS COMPETITION. — Apart from long distance competition, there are several instances of shorter runs where fierce strife has arisen and nowhere more so than along the Clyde Banks, where both *Caledonian* and *G. and S. W.* lines competed for the traffic.

The *Caledonian* ran 32 minutes non-stop trains from Glasgow Central to Gourock Pier, a distance of 26.1 miles (42.1 km.) and this, in spite of the tortuous nature of the track which caused so much comment that an extra five minutes had to be tagged on.

The *G. S. W.* trains took 34 minutes for the 25.5 miles (40.2 km.) from St. Enoch to Prince's Pier, at Greenock, though gradients where rather severe in between. Their best train left Glasgow

at 4.03 p. m. and got to the pier at 4.47 a. m., whereas the *Caledonian* 4.08 p. m. train arrived at 4.40 (later on at 4.45). Both Companies' boats then raced to Dunoon, the former's, which left a little later, being slightly faster than the other.

d) South Eastern and L. C. and D. Rys.' competing lines. — With the exception of Folkestone, all important *South Eastern* towns used to be served by other Companies as well, but the heaviest competition took place on the Ramsgate, the Margate and the Dover lines.

Line.		Companies.	Distance.	
			Miles (1).	Km.
Charing Cross	Dover Pier	S. E.	77	123.9
Victoria	Do.	L. C. D.	78.5	125.2
Do.	Dover Marine	Southern.	80 1/4	129.1
Cannon St.	Dover Town.	S. E.	75.5	122.0
Holborn Viaduct	Do. Priory	L. C. D.	77 1/4	124.3
Charing Cross	Ramsgate	S. E.	86	138.4
Victoria	Do.	L. C. D.	79.5	128.4
London Bridge	Do.	Do.	76.5	124.7
Charing Cross	Margate	S. E.	21 1/4	146.8
Victoria	Do.	L. C. D.	74	119.1
London Bridge	Do.	Do.	71	114.3

(1) As shown in *Bradshaw*.

In 1889, both Companies' best trains took 1 h. 36 m. from London to Dover, the *Chatham*, for the 74 miles (119 km.) form Herne Hill, the *S. E.*, for the 75.5 miles (121.5 km.) from Cannon St. It was only after many years' running of duplicate boat trains to the same timing that the two Companies came to their 1900 working agreement.

The same thing occurred on the Ramsgate and Margate lines (1) which admit of a number of alternatives.

e) The coming of the Great Central. — When the former *Manchester, Sheffield and Lincolnshire* sent a long tentacle down to London (1899) it was natural to expect that competition with its neighbours for London, Nottingham and Sheffield traffic should be awakened, but the repercussion of these new services was considerably greater than this and this line affords a particularly interesting example of far reaching and, to some extent, unforeseen results.

(1) Distances from London to Ramsgate, now are as follows :

Cannon St. and Ramsgate, via Chislehurst and St. Mary Cray spur, 76.9 miles (123.7 km.) ;

Charing Cross and Ramsgate, via Asford and Minster (*S. E.)*, 85 miles (138.2 km.) ;

Charing Cross and Ramsgate, via Folkestone, Dover and Deal, 99.6 miles (160.3 km.) ;

Victoria and Ramsgate (old *L. C. D.* direct line), 79.3 miles (127.6 km.).

Express trains run over all these routes, none of which have easy gradients. The ruling gradient of the Victoria Chatham and Margate route is 1 in 100 for 31 miles (49.9 km.) ; there are besides, 12 miles (19 km.) of 1 in 132 (7.5 mm. per m.).

We have shown the principal gradients of the old *S. E.* line as far as Dover (fig. 9). Beyond this on the Deal and Ramsgate line, there is a rise of 1 in 70 (14 mm. per m.) both from Dover and from Deal, extending 2 1/2 miles from Dover and 1 1/2, from Deal (4 and 2.4 km.).

Fig. 12. — *G. W., L. M. and S.* and *L. and N. E.* Railways' competitive lines between London, Lancashire and the Midlands.

Alternative lines of the *L. M. and S. Ry.*, of the former *Midland Ry.* and of the *G. W. Ry.* and
Joint lines of the *Met. and G. C. Jnt.* and of the *G. C. and G. W. Jnt.* Railways are also shown.

In 1903, when the *G. C.* had got into its stride, it accelerated its main expresses and both the *Midland* and the *G. N.* had to follow suit. The former had shortened its own route in 1901 (building its direct line through Cheadle Heath and cutting out Stockport) with the effect of starting competition with the *L. N. W.* for the Manchester traffic. The best times by the *G. C.* then were :

To Leicester, 105 min., for 103 miles (165.7 km.) ;

To Nottingham, 133 min., for 126.5 miles (203.7 km.) ;

To Sheffield, 170 min., for 164.5 miles (264.7 km.) ;

To Manchester, 230 min., for 206 miles (322.9 km.).

The 4 1/4 hours from London to Manchester by the *L. N. W.* and *Midland* were gradually cut to 3 h. 30 m. by the *L.N.W.*, 3 h. 35 m. by the *Midland*, besides 3 h. 40 m. by the *G. C.* who had started the affray, but the two latter Companies were unable to maintain their timings, which were eased out to 3 h. 40 and 4 h. 10 m. respectively though they still

included the *Midland*'s longest non-stop runs (1).

The *Midland* and *G. N.* competition thus awakened by the *G. C.* more especially affected the West Riding district, the best times being curtailed by some 20 minutes over each line.

« Voyageur » has rightly pointed out that apart from actual competition, the *G. C.*'s London extension was responsible for the establishment of much cross country running, and this was due to so simple a cause as the construction of the short spur connecting Woodford and Hinton (*G. C.*) with Banbury, on the *G. W.* Through services between Southampton and York, were immediately run this way and others between Bournemouth and Newcastle followed in 1902. Next came the 1905 « Ports to Ports » express (Barry, Cardiff and Newport to York and Newcastle). Owing to the length of these runs, restaurant car facilities were necessary and, of course, they had to be extended to other services as well.

Similar inter-Company runs from industrial centres to seaside resorts followed in the natural course of things (2) but their origin should be traced to the *G C.'s* venture.

(1) St. Pancras to Cheadle Heath, 181.3 miles (291.8 km.);
St. Pancras to Chindley 169.5 miles (272.8 km.);
St. Pancras to Manchester (conditional), 217.5 miles (350 km.).
This run was accomplished in 4 h. 10 m. (till the War).

(2) The « Sunny South Express » has been run by the *L. N. W.* and *L. B. S. C.* since 1904.
The *G. W.* and *L. S. W.* next started their Birkenhead-Bournemouth trains;
The *L. N. W.* and *Midland*'s Liverpool (and Manchester) and Bournemouth services through Birmingham and *S. and D.* were started in 1910.
Again, the Aberdeen Penzance service, the longest of all, was started in 1921 and runs over the old *G. C.*'s main line.

f) THE G. W. CUT-OFFS AND G. W. AND L. M. S. COMPETITION. — In spite of the *G. W.*'s original lines having been magnificently built and splendidly located, they followed roundabout routes, which prevented any effective competition with such of its neighbours as had direct routes to the places they both served. But a systematic policy of building long cut-offs and short by-pass lines has enabled the *G. W.*, through the straightening out of its main lines, to compete successfully both with the *L. S. W.* and the *L. N. W.* Railways.

We have previously dealt with the former's Weymouth and Plymouth lines. The *G. W.* next attended to its South Wales Route, in spite of there being no competition and built the 30 1/4-mile Badminton to Wootton Bassett and Patchway cut-off which shortened the distance by 12 miles and enabled the *G. W.* to schedule its first mile a minute long distance run (2-hour Bristol express) over 118.5 miles (190.7 km.).

Next, the Midlands and West of England traffic was catered for. Running powers were obtained over the Midland's competing route (1) and the *G. W.* built 50.5 miles (81.3 km.) of line from Tyseley (near Birmingham) to Cheltenham Spa, giving direct connection between Wolverhampton and Birmingham on the one side, Devon and Cornwall on the other.

There remained the Birmingham line's considerable detour through Didcot, and this was next shortened by no less than 18.5 miles (29.8 km.), through the building of the *G. C. and G. W. Joint* High Wycombe line. But the *L. N. W.* had not remained inactive during this time and had gradually cut the time of its Birmingham expresses from 2 h. 20 m. to

(1) Between Standish Jn. and Yate.

2 hours, which timing was adopted by the *G. W.* on the opening of its new line. An agreement was come to between the two Companies maintaining this as minimum time and this arrangement has been adhered to, though stoppages at Leamington Spa (*G. W.*) and at Coventry (*L. M. S.*) have been inserted since (1). Several of the *G. W.* trains include slip carriages (3).

The traffic from the South and West to Birmingham and Manchester is sufficient to warrant two Companies — the *G. W.* and *L. M. S.* competing for it, and there is no great difference in the overall time from Bournemouth to Manchester by either of the two routes (2).

g) Great Western and London Midland and Scottish Rys. — Both Companies run express train services from London to Chester and compete for intermediate traffic as well as for that between extremes.

Table 46.

SOME GREAT WESTERN AND LONDON MIDLAND AND SCOTTISH COMPETITIVE SERVICES.

Section.	Company.	Distance		Time of departure.	Time spent.	Speed	
		Miles.	Km.			Miles/h.	Km./h.
G. W. Ry. and **L. M. & S. Ry.**							
Paddington-Banbury	G. W.	67.5	105.7	R 3.54 p. m.	1.11	57.0	91.7
Euston- Do.	L. M. S.	77.5	124.7				
Paddington-Birmingham	G. W.	110.5	161.7	11.10 a. m.	2.00	55.3	89.0
Euston- Do.	L. M. S.	112.8	181.5	11.10 a. m.	2.00	56.4	90.8
Paddington-Wolverhampton	G. W.	123.5	198.7	11.10 a. m.	2.25	51.1	82.2
Euston- Id.	L. M. S.	125 8	202.4	11.30 a. m.	2.30	50.3	81.0
Paddington-Chester.	G. W.	195.0	313.8	11.10 a. m.	4.16	45.7	73.5
Euston-Crewe-Chester	L. M. S.	179 3	288.6	11.50 a. m.	3.20	53.8	86.6
Paddington-Birkenhead.	G. W.	210.5	338.8	11.10 a. m.	4.50	43.6	70.2
Euston- Do.	L. M. S.	194 3	312.7	11.50 a. m.	3.50	50.7	81.6
Birmingham (Snow Hill)-Bristol	G. W.	159.0	98.8	11.20 a. m.	2 12	72.2	44.9
Do. (New Street) Do.	L. M. S.	142.9	88.8	1.37 p. m.	1.55	74.5	46.3

(1) Some of the *G. W.*'s Winter 1933-34 Birmingham expresses have been decelerated.

(2) The *L. M. S.* « Pines Express » travels via the *Somerset and Dorset Jnt. Ry.* to Cheltenham Spa and through Birmingham, in Winter. In Summer the latter place is cut out and it runs via Walsall.

The *Southern Ry.* maintains the other route as far as Reading, and the *G. W.* beyond. In 1930, the two companies' trains reached Crewe at one minute interval and continued together to Manchester.

(3) Here are a few instances :

High Wycombe and Banbury	9.43 a. m.	41 minutes.
Do. Leamington Spa.	Do.	1 h. 10 m.
Paddington and Banbury	2.10 p. m.	1 h. 12 m.

h) Pooled G. W., L. M. S. and L. N. E. services. — The two latter Companies, and later on the *G. W.* as well, recently concluded pooling agreements concerning their competitive lines and since then, each of the three Companies has advertised all services between towns coming within the scope of these agreements, whether by its own or by the other Companies' lines.

In spite of the grouping, the northern trains of the former *L. N. W.* and *Midland* on the one hand, of the *G. C.* and *G. N.*, on the other, leave their own London termini as formerly. Table 47 quotes instances of quickest times and distances and shows the former Companies.

Table 47.

BEST SERVICES FROM LONDON TO THE MIDLANDS BY COMPETITIVE ROUTES.

(See fig. 12.)

Trains.	Railway Company.	Distance		Time of departure.	Time spent.	Speed	
		Miles.	Km.			Miles/h.	Km./h.
London and Leicester	G. C.	103.1	165.7	**3.20 p. m.**	**1.48**	**57.3**	**92.2**
	Mid.	99.1	159.5	**9.00 a. m.**	**1.46**	**56.0**	**90.1**
London and Nottingham	G. C.	126.5	203.6	3.20 p. m.	2.06	58.1	93.4
	G. N.	128.3	169.4	10.05 p. m.	2.48	46.8	75.3
	Mid.	123.5	198.7	**9.00 a. m.**	**2.09**	**57.4**	**92.3**
London and Sheffield	G. C.	164.7	265 1	3.20 p. m.	3.06	53.5	86.1
	G. N.	161.3	259.5	7.25 a. m.	3 21	48.1	77.4
	Mid.	158.5	255.8	11.55 a. m.	3.02	52.2	84.0
London and Manchester	L. N. W.	188.5	302.6	**6.00 p. m.**	**3.15**	**58.0**	**93.3**
	G. C.	206.0	331.9	4.55 p. m.	4.05	50.2	80.8
	Mid.	188.5	303.4	R12.20 noon	3.57	48.9	78 6
London and Liverpool	L. N. W.	193·8	311.9	**6.05 p. m.**	**3.20**	**58.1**	**93.4**
	Mid.	218.5	351.8	12.25 noon	4.50	45.2	72.7
London and Leeds	G. N.	185.7	299.0	R 4.02 p. m.	**3.13**	**58.1**	**93.4**
	Mid.	197.8	318.4	10.00 a. m.	3.46	52.5	84.5
London and Bradford	G. C.	204.0	328.3	10.00 a. m.	4.40	43.5	70.5
	G. N.	195.3	314.3	11.20 a. m.	3.50	50.9	81.9
	Mid.	211.3	340.1	11.55 a. m.	4.08	51.1	82.2
London and Halifax.	G. C.	202.0	325.1	3.20 p. m.	4.43	42.2	67.9
	G. N.	201.0	323.5	4.45 p. m.	4.22	46.0	74.0
	Mid.	208.5	335.6	4.55 p. m.	4.33	45.5	73.2
London and Huddersfield	L. N. W.	203.3	327.2	6.10 p. m.	4 12	48.4	77.8
	G. C.	191.3	307.8	10.00 a. m.	4.10	45.9	73.8
	G. N.	190.8	307.1	1.30 p. m.	4.35	41.6	67.0
	Mid.	204.0	328.3	2.00 p. m.	4.40	43.7	70.3

VI-5. — **Joint lines.** — Owing to the interweaving of several Companies' lines, joint lines belonging to two or more Companies have sprung up. In some cases, each of the owning Companies runs its own trains and supplies its own rolling stock; in others, these are provided by a special Joint Committee; several of these Joint Concerns have disappeared when engulfed in the merged groups, but others subsist.

They often are important assets of one or other of the parent Companies, especially when they stretch far into foreign territory and allow the parent Company's trains to reach towns which, otherwise, they would be unable to serve. Here are a few instances :

a) The former *Great Northern and Great Eastern Jt. Ry.* (123 miles = 198 km.) now obsolete, from Huntingdon and March to Lincoln and Doncaster, enabled the Harwich *Great Eastern* trains to run into York, and the *Great Northern*'s to Harwich (1);

b) The *Midland and Great Northern Ry.*, a West to East 183-mile (295 km.) cross country route, gave the constituting Companies direct access to Yarmouth and Lowestoft, in *Great Eastern territory* (2);

c) The *Somerset and Dorset Ry.* (*L. S. W.* and *Midland*) (101 miles = 162 km.), from Bath and Burnham to Broadstone, near Bournemouth. This is an important extension of the Western branch of the *Midland Ry.*'s « fork » (fig. 13) which enables the *L. M. S. to* run its own trains to the South Coast (3);

In accordance with a recent agreement, one of the owning Companies now supplies locomotives, rolling stock and staff and the other attends to the permanent way and buildings.

d) The Shrewsbury district lines (*L. N. W.* and *G. W.* Railways) which aggregate 83 miles (134 km.), and which include the important North and South Shrewsbury and Hereford line (fig. 13) (4);

e) The same Companies jointly own several lines in the Chester district, including those from Chester to Birkenhead and to Warrington, which give the *Great Western* connections with Liverpool and Manchester (5);

f) The *Midland and South Western Jn. Ry.* (Andoversford and Andover Jn.);

g) In Scotland, the *Portpatrick and Wigtownshire Ry.*, from Castle Douglas to Stranraer, used to belong to four Companies : the *Caledonian*, the *G. and S. W.*, the *L. and N. W.* and the *Midland*, all of which have now been merged in the *L. M. S. Ry.*

Two other joint lines are worthy of note, for they have several distinctive features.

h) The *Cheshire Lines Committee* formed by the *Midland*, the *G. N.* and *G. C.* Railways operates an important East and West system (161 miles = 228 km.) in the Liverpool and Manchester district comprising the Liverpool, Warrington and Manchester, the Manchester and Chester and the Liverpool and Stockport lines (fig. 15). This enables the *L. and N. E. Ry.* to run trains to the West of Manchester. The *C. L.* have their own rolling stock but the *L. N. E.* (as successor of the *G. C.*) provides the locomotives;

i) The last of the joint lines we have

(1) Route of the « Harwich Continental Boat Train ».

(2) Through trains are run from Liverpool and other places.

(3) Route of the « Pines Express ».

(4) Route of the North to West expresses.

(5) The *G. W.* boat expresses run to Birkenhead.

TABLE 48.

JOINT RAILWAY THROUGH EXPRESSES.

COMPANY AND SERVICE.	Distance		Time of departure.	Time spent.	Speed		
	Miles.	Km.			Miles/h.	Km./h.	
L. M. S. and **Midland Gt. Northern Ry.**							
Liverpool-Nottingham-Melton Constable, Cromer-Yarmouth-Lowestoft . . .	270.8	444.8	10 05 a. m.	7.51	37.2	59.8	
Ch. L., L. N. E. and former **G. N. & N. E. Jt. Ry.**							
Liverpool-Manchester-Sheffield-Spalding-Parkeston Quay	267.8	431.0	2.20 p. m.	6.56	38.4	61.8	
Cheshire Lines Committee.							
Manchester-Liverpool	34.0	54.0	9.00 a. m.	0.45	45.5	73.3	1 stop.
Manchester C.-Warrington C. . .	15.7	15.7	8.30 a. m.	0.18	52.3	84.2	
Liverpool-Manchester-Harwich . . .	267 8	431.0	2.20 p. m.	7.06	39 7	60.6	
L. M. S. and **Somerset and Dorset Ry.**							
Bournemouth-Wolverhampton-Liverpool.	253.8	408 4	10 20 a. m.	7.03	36.0	57.9	Pines Exp.
Do. Manchester.	267.0	429 7	10.20 a. m.	6.30	41.1	66.0	Do.
Southampton-Wolverhampton-Liverpool L. St.	277.0	445.8	10.12 a. m.	7.11	38.6	62.2	Do.
Bournemouth-Gloucester-Leicester-Nottingham-Lincoln	255.3	410 8	9.35 a. m. S	7.56	32.4	52.1	
G.C. and **G.W. Jt. Ry.**							
Paddington-Princes Risborough . . .	36.5	54.7	Several.	0.42	49.7	80.0	
Marylebone-Princes Risborough . .	36 0	57 9	Do.	0.48	41.5	66.8	
Paddington-High Wycombe	28.0	45.1	Do.	0.32	49.9	80.3	
Marylebone-High Wycombe	27.8	44.8	Do.	0.34	41.7	67.1	
Former **L. and N. W.** and **G.W. Rys.**							
Crewe-Shrewsbury	32 5	52.3	1.25 a. m.	0.43	45 3	72 9	
Shrewsbury-Hereford	50.8	81.8	1.50 a. m.	1.05	46 9	75 4	

to notice is situated in the London district. When the *Manchester, Sheffield and Lincolnshire* ran an extension to London and became the *G. C. Ry.*, it was found convenient and economical, to use the *Metropolitan Ry.*'s Verney Jn. line, between Quanton Rd. and Harrow, and only to build a short stretch of railway into the new Marylebone terminus. This was the origin of the *Met. and G. C. Jnt. Ry.* (fig. 12).

But misunderstandings arose, so the *G. C.* decided to build an alternative line, and did so in alliance with the *G. W.*, who also wanted a shorter route. Thus the *G. C. and G. W. Jnt. lines* came into existence from London to Princes Risborough, with a connecting branch to Aylesbury.

The two *Great Central* routes are roughly as long as each other, but the new

G. W. route through Oxford to Banbury and Birmingham, is considerably shorter than its former line through Didcot. This has enabled it to compete with the *L. and N. W.* route, both Companies' lines having approximately the same length and running at no great distance from each other.

TABLE 49.

DISTANCES FROM PADDINGTON AND MARYLEBONE TO AYNHO, OXFORD AND CLAYDON by the G. W., G. C., and G. C. & G. W. Jt. Rys. (fig. 12.)

SECTION OF LINE.	Company.	Via	Distance	
			Miles.	Km.
Paddington-Aynho (Banbury)	G.W.	Didcot	80.5	129.5
Do.	G.W.	Princes Risborough	61.5	99.0
Paddington-Oxford	G.W.	Didcot	63.5	102.2
Do.	G.W.	Princes Risborough	55.3	89.0
Marylebone-Claydon	G.C.	Princes Risborough	41.5	66.8
Do.	G.C.	Aylesbury	38.3	61.6

The *Metropolitan and Great Central Jt. Ry.* owns 51 miles (82 km.) of railways and the *Great Central and Great Western Jt.*, 41 miles (66 km.).

VI-6. — **Transverse and cross country lines.** — A number of important provincial centres have been joined to the principal industrial regions, ports and holiday resorts, without passing through London and most of these lines have their own through expresses. Owing to their lay-out, the *Southern* and *G. W.* Railways have fewer of them than have the other Companies.

a) The *Southern Ry.* has a South Coast line from Ashford to Southampton, and another 66 miles (106 km.) long, from (Dover) Tonbridge through Redhill to Reading, is roughly parallel with it and situated half way up to London;

b) The *Great Western* has two West to North lines, from Cornwall and Devonshire to the Midlands, Liverpool and Manchester, running from Newport through Hereford to Shrewsbury (and Crewe), and from Bristol to Birmingham;

c) Both Northern Companies have a series of East to West lines running across Staffordshire, the Midlands, and others from Newcastle to Carlisle, and Glasgow to Edinburgh. Many of them have been inherited from local Companies and the following may be quoted :

The *Stratford-on-Avon and Midland Jnt. Ry.* from Blisworth westwards;

The *North Staffordshire Ry.* in the Stoke-on-Trent district;

And in line with Manchester and the Midlands :

The *Hull and Barnsley Ry.*, from Hull to Cudworth (in the East) ;

The *Lancashire, Derbyshire and East Coast* Ry.

And in the West, the *Cheshire Lines Committee* (fig. 14*b*).

TABLE 50.

SOME CROSS COUNTRY TRAIN SERVICES.

(1)	COMPANY AND THROUGH SERVICES.	Distance Miles.	Distance Km.	Time of departure.	Time spent.	Speed Miles/h.	Speed Km./h.	
	Southern Ry.							
Tr.	Deal-Ashford-Guilford-South'ton-Bournemouth (W.)	199 5	321.1	R 10.25 a.m.	6.05	19.1	30.7	
Tr.	Ashford-Lewes-Bournemouth (W.)	130.8	210.5	2.56 p.m.	4.41	30.1	48.4	
	Brighton-South'ton-Salisbury-Plymouth N. Rd.	241.9	388.3	R 8.35 a.m.	6.19	38.2	61.5	
Tr.	Brighton-Reading	76.1	122.5	12.20 noon	1.55	39.7	63.9	
	Great Western Ry.							
	Plymouth-Birmingham	227.3	365.7	10 30 a.m.	6.10	38.2	61.5	
Diag.	(Newport) Hereford-Shrewsbury-Pontypool Rd.	82.3	132.5	**11.53** a.m.	**1.42**	**52.5**	**84.5**	
	London Midland and Scottish Ry.							
Tr.	Liverpool (L. St.)-Leeds (New)	74 3	119.6	9.00 a.m.	2.04	35.8	57.6	
Tr.	Do. (Exch.)-York	111.8	180.0	10.45 a.m.	2.57	38.0	61.1	
Tr.	Birming. (N. St.)-Peterboro (E.)	81.0	130.4	4.00 a.m.	2.12	36.8	59.2	
Tr.	Oxford-Cambridge	77 0	123.9	10.45 a.m.	2.32	30.4	48.9	
Tr.	Leeds (Well)-Barrow (C.)	92.0	148.1	4.03 a.m.	2.59	30.7	44.9	
Diag.	(Paignton)-Bristol-Derby (Bradford)	129.8	208.9	12.55 noon	3.05	45.3	72.9	The Devonian.
Diag.	(Bournemouth) Bath-Birmingham (Manchester)	93.5	150.5	12.30 noon	2.15	41 2	66.3	The Pines Ex.
Diag.	Manchester-Crewe-Shrewsbury (Bristol)	63.3	101.9	11.55 p.m.	1.45	36.2	58.2	
	Shrewsbury-Hereford	50 8	81.8	1.50 a.m.	1 05	46.9	75.4	
Diag.	Manchester (Ln. Rd.)-Swansea (Vict.)	178.5	287.3	3.05 a.m.	6.13	28.8	46 4	
Diag.	Do. -Bournemouth (W.)	249.0	400.8	10.00 a.m.	6.33	38.0	61.1	
	London & North Eastern Ry.							
Tr.	Manchester L. Rd.-Scarborough	126.0	202.7	11.45 a.m.	2.25	51.5	82.9	
Tr.	Do. -Cleethorpes.	112.0	180.2	10.03 a.m.	3.17	34.1	54 8	
Tr.	Liverpool-Penistone-Hull.	133.0	214.0	1.18 p.m.	3.27	38.6	62.2	
Tr.	Leicester-Melton-Mowbray-Sutton, Sea.	105.0	161.7	R12.35 noon	2.55	35.0	56.3	
Tr.	Leeds-Selby-Hull	51.5	82.9	R11.00 a.m.	1.07	46.1	74.2	
Tr.	Newcastle-Carlisle	60.3	97.1	**0.40** night	**1.20**	**45.2**	**72.7**	Non-stop.
Diag.	Edinburgh-Carlisle	98.3	158.2	12.05 noon	2.31	59.1	63.0	Thames Forth Exp.
	(King's Cross) Manchester-Leeds-Newcastle	140.3	225.8	9.05 a.m.	4.46	40.7	65.5	
Diag.	Manchester L. Rd.-Swansea-Vict.	178.5	287.3	3.05 a.m.	6.13	28 8	46.4	20 stops.
Tr.	Lincoln-Leicester-Bristol	189.0	291.1	8.52 a.m.	4.50	39.1	62.9	9 Do.
Tr.	Liverpool-Manchester-York	111.8	179.9	10.45 a.m.	2.57	38.0	61.2	6 Do.
	Leeds-Well.-Bristol	206.0	331.6	10.47 a.m.	4.50	42.6	68.6	5 Do.
	Birmingham New St-Peterborough East	81.0	130.4	4.00 a.m	2.12	36.8	59.2	8 Do.

(1) Tr. = tranverse line. — Diag. = diagonal line.

The former *Manchester, Sheffield and Lincolnshire* main line, from Manchester to Great Grimsby.

Further North :

The old *Newcastle and Carlisle Railway (L. N. E.)* and the *Portpatrick and Wigtownshire Ry.* beyond, connecting with Stranraer.

Besides the East-to-West Edinburgh and Glasgow lines.

Fast expresses run on them all.

Fig. 13. — « Forks » of the *L. M. and S. Ry.*
(Diagram shows the location of the *G. W.* and *L. and N. W. Jnt. Ry.* and the *Somerset and Dorset Ry.*)

VI-6*b*. — **Trans-London services.** — See Appendix (Chapter IX*bis*).

VI-7. — « **Forks** ». — The *L. M. S.* North and South line is divided into two main branches in Birmingham; one of them runs to London, the other, to Bristol and Bath, giving connections from the North and the Midlands, with South Wales and the West of England (fig. 13). The « fork »'s Western branch also feeds two joint railways, the *Midland and South Western* and the *Somerset and Dorset*, which reach Southampton and Bournemouth.

TABLE 51.

OVERALL SPEEDS, BIRMINGHAM AND BRISTOL LINE (L. M. S.) (Fig. 13.)

LINE OR SECTION.	Speed Miles.	Speed Km.	Time of departure.	Time spent.	Speed Miles/h.	Speed Km./h.	
(Paignton) Bristol-Derby (Bradford) . .	129.8	208.9	12.55 noon	3.05	45.3	72.9	Devonian.
(Bournemouth) Bath-Birmingham .	93.5	150.5	12.30 noon	2.15	41.2	66 3	Pines Exp.
Bristol-Gloucester	37.0	59.5	**2.48** p. m.	**0.38**	**58.4**	**93 9**	
Bath-Gloucester	42.0	67.6	**12.05** noon	**0.47**	**53.6**	**86.3**	
Mangotsfield-Gloucester	32.0	51.5	**10.30** a. m.	**0.31**	**61.9**	**99.6**	
Bristol-Cheltenham	43.5	70.0	**R 2.25** a. m.	**1.02**	**53.8**	**86.9**	
Weston-super-Mare—Birkenhead. .	216.5	348.5	*8.20* a. m.	*6.11*	*56.3*	*90.6*	*Shakespeare Exp.*

In the other direction, the *Great Western Ry.* trunk line from the South West to Bristol also splits into two branches, the one running to London, the other northward to Birmingham, in direct competition with that of the *L. M. S.* Both Companies run fast through West to North expresses.

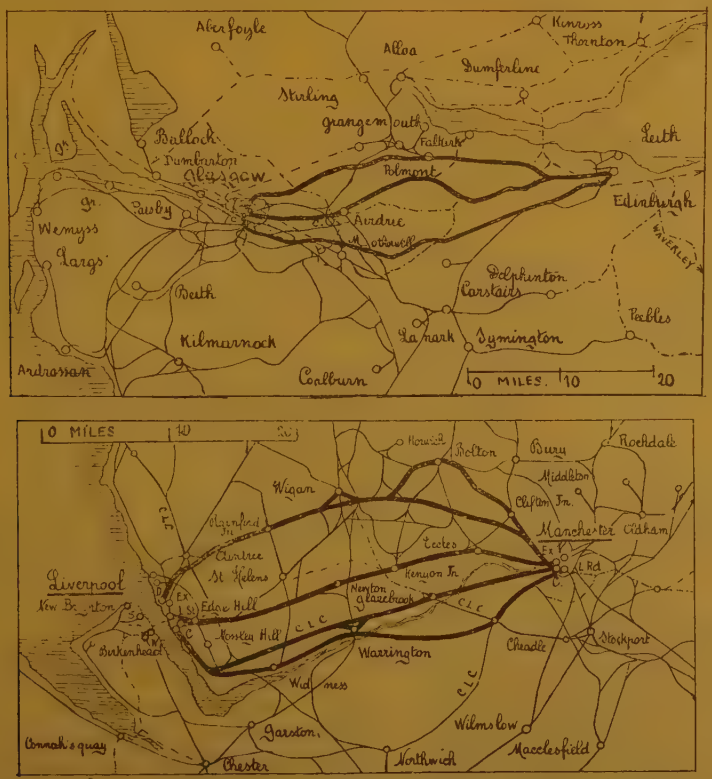

Fig. 14. — Conjugated railway centres.
a) Glasgow and Edinburgh. — *b*) Liverpool and Manchester.

VI-8. — « **Conjugated** » **railway centres.** — The *L. M. S.* has two remarkable examples of conjugated railway centres, consisting in important places so tied up that each of them immediately responds to any improvement or curtailment of the other's prosperity.

Before the grouping, these « conjugated » towns were served by lines belonging to different Railway Companies, and, even now, both the East and West Coast have their own lines between them.

In both instances, the *L. M. S.* main line from Euston to the North crosses the districts : at Warrington, midway between Liverpool and Manchester, and at Carstairs, between Glasgow and Edinburgh.

Liverpool and Manchester. — The London trains run along the main line to Crewe, where they branch off to either town. Running northwards, the Liverpool and Manchester trains join the main line at Preston, thus completing the quadrilatery. The four Liverpool and Manchester transverse lines are shown in figure 14*b*.

The case of Glasgow and Edinburgh is similar (fig. 14*a*). The London trains of the former *Caledonian Ry.* diverge at Carstairs and run East to Edinburgh and West to Glasgow, whilst trains running North from these places join in Larbert the main line that has passed between them. In this instance, there are but three transverse inter-city lines, and two of these only have fast trains.

Table 52.

TRAIN SERVICES ON THE TRANSVERSE LIVERPOOL AND MANCHESTER AND GLASGOW AND EDINBURGH LINES (fig. 14).

Line.	Company.	Distance		Time of departure.	Time spent.	Speed	
		Miles.	Km.			Miles/h.	Km./h.
Manchester and Liverpool, via							
Earlestown, Exch.	L. M. & S.	31.4	50.5	2.02 p. m.	0 38	49.6	79.9
Bolton, Wigan Vict.	Do.	37.0	59.5	6.32 p. m.	0.45	49.3	79.4
Warrington	Ch. L.	37.3	60.0	R 10.00 a. m.	0.20	53.3	85.8
Farnmouth	Do.	34.0	54.7	9.25 a. m.	0.50	40.8	65.7
Edinburgh and Glasgow, via							
Holytown.	L. M. & S.	46.3	74.5	1.00 p.m. S	1.06	42 1	67.7
Polmont, Castle Carey. . . .	L. & N. E.	47.3	76.1	4.28 a.m.	1.00	47.3	76.1
Bathgate, Airdrie, Coatbridge .	Do.	47.8	76.9	9.55 p.m.	1.17	37.2	59.8

VI-9. — **Inter-Company lines.** — These also are due to the previous co-existence of so many Companies, each of which offered the public all it could, including through carriages and through trains to all possible places on their own and on foreign systems. It is noteworthy that they should have been able to do so when agreements between three and sometimes four Companies were involved. Since the grouping, most of these advantages have necessarily been maintained.

TABLE 53.

SOME INTER-COMPANY THROUGH TRAINS.

COMPANY AND THROUGH TRAIN SERVICES.	Distance		Time of departure.	Time spent.	Speed		
	Miles	Km.			Miles/h.	Km./h.	
S. and G. W. via Salisbury.							
Cardiff-Bristol-South'ton-Brighton . .	184.8	297.4	R 10.45 a.m.S	4.48	38.5	62.0	
via Basingstoke-Reading.							
Bournemouth-Birmingham-Birkenhead .	269.3	418.9	9.30 a. m.	7.59	33.7	54.2	
Portsmouth-Wolverhampton L. L. . .	169.0	272.0	2 36 p. m.	5.19	31.8	50.0	
via Reading-Redhill.							
Birkenhead-Banbury-Brighton	269.0	432.9	8.00 a. m	7 27	33.5	54 1	The Sunny South Ex.
S. Ry. and L. M. & S. Ry. via Willesden Jn. and East Croydon.							
Birmingham (New)-Brighton			11.30 a. m.	3.57			
Do. -Eastbourne . . .			Do.	4.40			
Birmingham-Chatham-Ramsgate . . .			12.30 noon.	5.31			
S. Ry. and L. & N. E. Ry. via Basingstoke-Banbury.							
Bournemouth - Sheffield L. N. E. - Newcastle	361.4	579.4	R 8.00 a. m.	10.18	35.1	54.1	
Portsmouth-Eastleigh-Sheffield . . .	220.3	354 6	10.06 a. m.	6.59	31.8	51.0	
G. W. Ry. and L. & N. E. Ry. via Banbury.							
Swansea-Sheffield-York-Newcastle . .	335.8	540.4	9.40 a. m.	8.38	39.1	62 9	
Swindon-Oxford-Sheffield-York . . .	210.3	338.5	9.05 a. m.	5.58	32 5	52.3	
Bournemouth-Sheffield-Newcastle. . .	373.8	601.5	11.15 a. m.	10 55	34 2	55.0	
G. W. Ry. and L. M. & S. Ry.							
Bradford-Birmingham-Bristol-Paignton.	322.8	519.5	10.30 a. m.	8.12	39 3	63.3	The Devonian.

As a matter of fact, the East Coast, the *Midland* and West Coast and Anglo-Scottish lines should come under this heading. The East Coast's rolling stock was originally provided by the *G. N. Ry.* but over half a Century ago, the *East Coast Joint Stock* came into being, each of the partners still supplying motive power on its own system, and just a little beyond (1). The same applied to the other routes.

Inter-Company through expresses consist either of special stock belonging to one only of the Companies or on alternate days of complete trains provided by each of them or else of mixed trains made up

(1) The *G. N.* used to run 28 miles (45 km.) on *N. E.* territory, as far as York, and the latter Company, 57.7 miles (92.5 km.) into *N. B.* preserves, but this last arrangement was difficult to come to.

of sets furnished by each of the Companies. These are not turned over to a joint stock account.

Joint Committees, like the *Cheshire Lines*, which own their own rolling stock, are also, to all intents and purposes, joint (rolling) stock concerns.

The standard of inter-Company services is a high as that of the main line expresses and on special occasions are patronised to the same extent. For instance, on Bank Holiday last, when traffic was heavy on all main lines, the 8.20 a. m. Wolverhampton and Portsmouth express (*G. W. and Southern*) ran in six parts.

CHAPTER VII.

The express trains.

Some of the British crack trains are justly famous, and the Companies' constant endeavours towards their improvement have materially assisted the technique of locomotive and rolling stock building and operation. With the exception of the « Flying Scotsman » and, to a lesser degree, the « Cornish Riviera Ltd. », continental readers know but little about them, in spite of their being the English counterpart of the continental « de luxe » trains, and of their being made up of special rolling stock with diners by day and sleepers by night. Relief trains are scheduled during the Summer and in spite of this, on special occasions, they run in two, three and up to five parts. But differing in that from continental practice, many of them are crack cross country trains and others do not start from the Capital, but bring passengers up to their work in the morning and back to Manchester, Liverpool, Newcastle, Bournemouth or Brighton — to quote but a few instances — in the evening.

Many of these expresses comprise several sections which are detached en route and sent on to different destinations. Each section often includes restaurant cars which contribute to bring the total weight up considerably. The 5.45 p. m. ex-King's Cross (*L. N. E.*), the 16 or 17 cars of which weigh up to 516 or 570 tons is a typical example. Another is the 11.4 a. m. which carries through portions to Harrogate, Bradford, Leeds (including three separate dining cars) and Hull, besides a through Halifax coach. During the Summer season, most of these portions become separate trains.

The 10.35 ex-Euston is similarly made up and carries :

A brake composite to Pwllheli,
Composite third brake to Llandudno,
Brake composite, third dining and kitchen to Carlisle;
Brake composite to Windermere,
Another to Whitehaven,
Another to Blackpool (Talbot Rd.),
One to Swansea,
And a third to Stafford.

These sections return on five separate trains and in Summer, become three separate trains. The same applies to several of the « named expresses », particularly during the winter months. To quote but a single instance, the « Sunny South Express then carries :

Brake composites, Ramsgate to Liverpool;
Also Hastings to Liverpool;
Brake composites, kitchen, dining and third brake to Manchester;
Brake composite to Birmingham.

Some of these trains are « limited expresses » — though why they should be so designated is a mystery as they frequently run in several sections; a few others are all-Pullman trains. We will pass the principal, then the limited expresses in review, adding a few words concerning the dying-out slip-carriages and deal with the all-Pullman trains, in the next Chapter, which concerns Pullman, dining and sleeping car services.

VII-1. — **Named L. N. E. and L. M. S. trains.** — Such names as the « Flying Scotsman » (East Coast Route) and the « Flying Dutchman » (*G. W.*) though unofficial, have been widely known for years and so constitute as good an advertisement as the names bestowed on boats, locomotives and Pullman cars. The Railway Companies have seen this advantage and have embarked on a general policy of naming all their best trains. Not only have the grouped Companies done so, but outsiders, such as the *Underground*, have followed suit, the latter having bestowed, since January 1915, the name « The Harrovian » on one of its suburban trains (1).

TABLE 54.

PRINCIPAL EXPRESSES — LONDON AND NORTH EASTERN RY.

NAME OF TRAIN.	Runs between	Distance		Time of departure.	Time spent.	Speed.	
		Miles	Km.			Miles/h.	Km./h.
1. London and Scotland.							
The Flying Scotsman	K. Cr. and Edinburgh.	392.7	631 9	10.00 a. m.	7.30	52.4	84.3
	Do. Glasgow.	440.3	708.6	10.00 a. m.	8.53	49.5	79.9
	Do. Aberdeen.	523.5	842.4	10.00 a. m.	11.30	45.5	73.2
The Aberdonian	K. Cr. and Aberdeen.	523.5	842.4	10.40 a. m.	11.40	44.9	72.2
The Night Scotsman	K. Cr. and Glasgow.	440.3	708.6	10.25 p. m.	10.27	42.1	67.7
	Do. Aberdeen.	523.5	842.4	10.25 p. m.	12.53	40.6	65.4
The Norseman	K. Cr. and Newcastle.	268.7	432.4	1.05 p. m.	5.20	50.4	81.1
The Lothian Coast Express	N. Berwick and Glasgow.	69.8	112.3	8.12 a. m.	1.38	47.3	76.0
The Highlandman	K. Cr. Edinburgh Inverness.	558.8	899.3	7.25 p. m.	13.20	41.9	67.4
	Do. Fort William.	558.8	899.3	Do.	13.53	40.3	64.9
The Fifeshire Coast Express	Edinb. and Dundee.	59.3	95.4	4.53 p. m.	2.02	29.1	46.8
	Glasgow and Do.	89.3	143.7	4.10 p. m.	2.45	32.5	52.3
2. Other lines.							
The Scarborough Flier	K. Cr. and Scarborough.	230.0	370.0	11.53 a. m.	4.00	57.5	92.5
The Garden Cities and Cambridge Buffet Express	K. Cr. and Cambridge.	58.0	93.3	9.35 a. m.	1.15	46.4	74.6
3. Alternative line via Leeds or Harrogate.							
The Queen of Scots	See Table 61 : Pullman trains.						
The West Riding Pullman							
The Harrogate Sunday Pullman							

(1) This Saturday train leaves Harrow at 8.13 a. m. and reaches Mansion House in 42 minutes, ending at Barking (20 miles = 32 km.). According to Bradshaw, the poor thing never returns...

Named London and North Eastern trains. — The « Flying Scotsman », though officially bearing this name since the War only, is the most famous of the *L.N.E.* and perhaps of the World's trains. A few data concerning its carreer are therefore not out of place.

It was first run towards 1850, and was then a 9.0 o'clock train with Manchester and Scotsland portions. In 1862, the time of departure was retarded to 10 a. m. Ever since, save on Sundays, the train has left London at that time.

It then carried first-class passengers only, later on, seconds as well. These were tentatively admitted in 1872 and definitely, in 1877.

The journey to Edinburgh took 10 1/2 hours, 30 minutes improvement on former services; in 1872, this was reduced to 9 h. 20 m. to Edinburgh and 11 hours to Glasgow. But as third-class traffic overloaded the train, it was transferred to the former 9.0 o'clock which, since then, has always been run as a relief, either preceding or following the « Scotsman ». In the Summer of 1876, this relief was shifted from 9.0 to 10.10 a. m. and the « Scotsman »'s timing from King's Cross to Edinburgh curtailed to the round 9 hours.

The « Flying Scotsman » having already become a kind of national institution, alterations of any kind were looked at with misgiving all the more as things seemed satisfactory as they were. But in 1888, the first East and West Coast race to the North suddenly broke out, when the announcement of a reduction of time from 9 h. to 8 h. 30 m. in the journey to Edinburgh had been announced. Racing times brought this down to 7 h. 26 m., after which the 8 h. 30 m. was simply reverted to. But for a 15-minute gain, it has remained so until recently, though night trains, which were usually lighter, were sometimes timed faster.

It is a curious fact that whereas dining cars were run as early as 1893, on the midday Scotch express, they were only introduced into the « Flying Scotsman »'s make up in 1900, a 20-minute luncheon stop at York having always been made. And this, though a brand new set of coaches had been provided in 1896.

During all this time, the « Scotsman » and its relief ran at a ten-minute interval, though both trains were shown in the time tables as leaving at 10 a.m. and arriving at 6.30 p. m. In reality, neither did. Both accomplished the journey in 8 h. 20 m., the first arriving in Edinburgh at 6.20 p. m. and the second leaving King's Cross at 10.10 a. m. (1).

Later, the relief was advanced to a 9.50 a. m. departure. It stopped at Doncaster, York (to change locomotives only) and Newcastle, whereas the real « Flying Scotsman », of course, left at 10 a. m. and stopped at Grantham, York, New-

(1) Other time table freaks, regarding this remarkable train, have followed. In 1901, for instance, the arrival in Edinburgh (at 6.15 p. m.) was no longer shown at all, because the train had sections for Glasgow, and for Perth, Dundee and Aberdeen only, and no Edinburgh portion at all.

In 1906, the Grantham and York stops disappeared in their turn and Newcastle only was shown, so that passengers from Grantham or York should travel by the second train.

Similar instances occur on the *L. M. S.* The 1933 public Summer time tables show the time of departure of two « Royal Scots » both leaving Euston at 10 a. m. and both running non-stop to Glasgow and Edinburgh respectively. As a matter of fact they do stop at Symington, for division, and at Carlisle No. 12 signal box, to change engines, but neither of these stops is of any use to the public, so they have been omitted.

castle and Berwick. In 1927, on four days a week, the relief ran non-stop from King's Cross to Newcastle (286.5 miles = 461.1 km.). This was just to get its hand in as from May 1st, 1930, the « Flying Scotsman » itself, started its non-stop Summer, London and Edinburgh runs over the entire distance of 392.7 miles. This is, by a large margin, the longest non-stop run in the World.

With this end in view, corridor tenders were provided so that a relief crew could be carried in the van and shifts changed half way. The locomotives carry 5 000 gallons (22.7 m^3) of water and pick up as much again in the six water troughs laid on they way; they consume 6 1/2 tons of fuel for the trip. They weigh 158.6 tons in service, and the train a maximum of 550 tons out of London, which weight is sometimes exceeded.

By January 1934, the « Flying Scotsman » will have left London nearly 23 000 times in 71 years and will have covered over 17 000 000 miles (27 000 000 km.), with but a single accident (1).

It has not escaped the general speeding up that is taking place, and its Summer runs are now made in 7 h. 30 m. As is customary, the first of them was accomplished in the allotted time, in 7 h. 26 m. gross (7 h. 19 m. net). The last word has surely not been said and a cut of a further 30 minutes is no longer an impossibility. These accelerations of a quarter of an hour or half an hour at a time are often criticised. Yet it is by the accumulation of such gains, and adding the quarters to the half hours, that the total journey time has been brought down from 10 h. 30 m. to 7 h. 30 m..., in nearly three quarters of a century.

Other important Anglo-Scottish expresses comprise the « Highlandman » to Inverness and Fort William, the « Aberdonian » and the « Night Scotsman », day and night trains to Aberdeen.

Two named *L. N. E.* trains, the « Loathian Coast » and the « Fifeshire Coast » expresses run from Glasgow, to the South East and North East respectively.

The « Scarborough Flier » branches off the main line at York where it turns off onto the Scarborough branch (2), a long distance for a seaside resort train of the kind. It now runs non-stop as far as York. The « Norseman » follows the same main line route, and continues further along it, to Newcastle. It is a London train, whereas the « West Riding Pullman », between the two places (but via Harrogate) is a Newcastle train.

b) **The London Midland and Scottish Ry.'s named trains.** — Since 1927 especially, this Company has extended the policy of naming its main trains, and the 1933 Summer time tables have further developments in this line, so that there now are some thirty of them which we have grouped as follows :

The trains of the West Coast Route, from Euston to Scotland, where the main line splits up into several directions.

The main line trains that turn off after a time on to important branches, beginning with the Liverpool and Manchester trains and continuing with the others;

The St. Pancras Scotch expresses;

(1) On October 10th, 1880, the up « Scotsman » derailed some distance north of Berwick, killing the driver and one of the guards.

(2) Owing to the closing of several stations, the York and Scarborough 42-mile (67 km.) branch now only has two intermediate stations, at Malton (21st mile, and at Seamer (39th mile).

Table 55.

LONDON MIDLAND AND SCOTTISH RY.'S EXPRESSES.

NAME OF TRAIN.	Running between.	Distance		Time of departure.	Time spent.	Speed	
		Miles.	Km.			Miles/h.	Km./h.
a) **Euston to Scotland.**							
The Royal Scot	Euston-Glasgow Cent.	401.5	646.1	**10.00** a. m.	**7.40**	**51.7**	**83.2**
Do.	Euston-Edinburgh.	400.0	643.7	R **10.00** a. m.	**7.40**	**51.7**	**83.2**
The Midday Scot.	Euston-Glasgow.	401.5	646.1	R 1 30 p. m.	8.00	50.2	80.8
	Euston-Glasgow.	400.0	643.7	Do.	8.00	50.0	80.5
The Night Scot	Euston-Edinburgh.	401.5	643.7	R 10.30 p. m.	8.45	44.5	71.6
The Royal Highlander.	Euston-Stranraer.	405.0	651.7	8.30 p. m.	9.22	43.3	69.7
	Euston-Inverness.	568.0	913.9	Do.	13.28	42.2	67.9
	Euston-Aberdeen.	540.0	869.0	Do.	11.50	49.0	79.0
The Granite City	Glasgow B.-Aberdeen.	153.0	245.9	R 5.30 p. m.	3.52	39.4	63.4
The Hebridean	Inverness-Kyle of Lochalsh.	82.0	132.0	7.25 a. m.	3.08	27.2	43.8
The Lewisman	Inverness-Kyle of Lochalsh.	82 0	132.0	10.10 a. m.	2.30	32.8	52.8
The St. John o' Groat (1)	Inverness-Wick.	161 3	259.5	4.10 p. m.	5.00	32.3	52.0
b) **Liverpool and Manchester trains.**							
The Merseyside Express	Euston-Liverpool (L. St.)	193.8	311.9	**6.00** p. m.	**3.15**	**58.4**	**93.3**
The Manxman (Summer)	Euston-Southport.	211.5	340.4	R 12 52 noon	5.13	35.0	56.3
The Mancunian	Euston-Manchester L.Rd. (ret. via Crewe).	188.8	304.0	R **9.45** a. m.	**3.15**	**58.1**	**93.4**
The Lancastrian	Euston-Manchester (ret. via Stoke).	187.0	301.0	R 12 05 noon	3.40	51.0	82.1
The Comet	Euston-Manchester	188.8	304.0	11.50 a. m.	3.30	53.9	86.8
	Euston-Liverpool L. St.	193.5	311.4	Do.	3.45	31.5	50.9
c) **Main line and branches.**							
The Ulster Express	Euston-Heysham (Belf.)	237.5	382.2	6.10 a. m.	5.00	47.3	76.4
The Lakes Express	Euston-Blackpool.	230.5	370.9	12.00 noon	4.52	47.4	76.2
	Euston-Windermere.	259.5	417.6	Do.	5 29	47.3	76.1
	Euston-Southport.	211.5	340.4	Do. S	**4.07**	**51.1**	**82.2**
The Irish Mail	Euston-Holyhead.	263.8	424.5	R**12.27** noon S	**5.10**	**51.1**	**82.2**
The Welshman (Summer)	Euston-Holyhead.	263.8	424.5	**11.15** a. m.	**4.40**	**56.5**	**90.9**
	Euston-Llandudno.	223 8	360.1	Do.	4.45	47.1	75.7
The Golden Sands Express	Rhyl-Bettws y Coed.	39.5	63.6	**10.15** a. m.	1.08	34.8	56.0
d) **St. Pancras to Scotland.**							
The Thames and Forth Express.	St. Pancras-Galashiels-Edinburgh. (via Nottingham).	408.8	657.9	9.00 a. m.	8.52	46.1	74.2
The Thames and Clyde Express	St. Pancras-Kilmarnock-Glasgow (via Leicester).	426 0	685.6	10.00 a. m.	8.50	47.6	76.6
The Irishman	Glasgow St. E.-Girvan-Stranraer.	99.8	160.6	R 9.17 p. m.	2.43	36.1	58.1
The Fast Belfast.	Glasgow St.E.-Stranraer.	99.8	160.6	3.43 a. m.	2.50	35.2	56.6
The Tinto	Glasgow C.-Lockerbie.	76.3	122.8	R 7.26 a. m.	2.02	37.5	60.3
The Yorkshireman	St. Pancras-Bradford.	211.3	340.0	4.55 p. m.	4.08	51.2	82.4

The inter-Company trains, which we have shown separately in table 53.

a) Euston and Scotland expresses. — The « Royal Scot » is the West Coast replica of the East Coast's « Flying Scotsman » and the time taken by both routes from London to Scotland has always been approximately identical. Since 1930, when the time taken by the East Coast Route was reduced to 7 h. 30 m. between London and Edinburgh, the West Coast brought its own down to 7 h. 40 m.

As the latter's main line does not run, as does the East Coast's, both to Glasgow and Edinburgh, the *L. M. S.* trains are made up of two sections which diverge at Carstairs, though they actually split at Symington (6 3/4 miles = 10.9 km.) before getting there. The first stop usually takes place at Carlisle, where locomotives are changed. But on April 27th, 1928, when the train was heavy — no rare occurrence — the two sections were run separately and for the first time, the Glasgow portion ran non-stop all the way from Euston to Glasgow, the longest non-stop run that has ever been attempted. Since then, when the train runs in two sections, the Symington stop is frequently cut out.

Besides the « Royal Scot », the *L. M. S.* runs a « Midday Scot » and a « Night Scot ».

The « Royal Highlander », similar to the East Coast's « Highlandman », runs non-stop to Crewe, where (in Summer), it is split into two sections, one of which runs non-stop to Perth (save for a service stop at Carstairs), and the other to Oban, with a first stop at Stirling (1).

(1) There is a service stop at Kingmoor, from 1.38 to 1.43 a. m. Kingmoor is 300.8 miles (484.1 km.) from Euston, whereas Carlisle No. 12 Box is only 298.2 miles (479.9 km.).

As on the *L. N. E.* several important trains such as the « Granite City » (1) run northwards from Glasgow, and others, start from Inverness. These comprise the « John o'Groat » (2) and the Kyle of Lochalsh boat trains (3), none of which are fast trains.

b) Manchester and Liverpool expresses. — These are the more important of the trains that branch off the West Coast line and some of them are routed through Stoke-on-Trent and Macclesfield.

« The « Comet » follows the main line to Crewe, where it branches off to Manchester; the « Merseyside » and the « Manxman » both run to Crewe and Liverpool.

The « Mancunian » runs from Euston to Manchester via Crewe and returns via Stoke-on-Trent, whereas the « Lancastrian » does the reverse.

Several expresses run both from Liverpool and from Manchester through Crewe to the South Coast resorts. The « Sunny South Express » reaches them through Kensington Jn. and Battersea Park and the « Pines Express » from Liverpool only, by means of the westerly branch of the *L. M. S.*'s « fork ».

c) Other expresses diverging from the main line are the « Ulster Express » to Heysham, and the « Lakes Express », to Windermere, neither place being far distant from it.

But this is not the case for the Holyhead line, where, besides the « Welshman » and two « Irish Mails » either way, there are a number of Summer expresses to the North Wales Summer resorts: Colwyn Bay, Prestatyn, Llandudno, Bangor,

(1) A name reintroduced in 1933. It existed before the War.
(2) Formerly the « Further North Express ».
(3) The « Hebridean » and the « Lewisman » bear these names since 1933.

etc., which bring holiday seekers from any number of places.

The « Golden Sands Express » was added to the list in 1931. It has the shortest run of any of the named trains and stops at many intermediate stations.

d) As with the former *Midland*, some of the *L. N. E.*'s expresses follow alternative routes. Thus the « Thames and Forth Express » runs via Nottingham and the « Thames and Clyde », via Leicester.

The « Yorkshireman » follows the same route as far as Bradford which has a *L. N. E.* Pullman train on Sundays. The *Midland* route is 16 miles (25.9 km.) longer, but the « Yorkshireman » takes only 16 minutes longer than the « Harrogate Pullman ».

Here again, several named trains start from Glasgow. They run at no great speed, along the former *G. and S. W.*'s line.

TABLE 56.

THROUGH EXPRESSES FROM THE L. M. S. TO THE GREAT WESTERN AND SOUTHERN SYSTEMS.

NAME OF TRAIN.	Runs between	Distance		Time of departure.	Time spent.	Speed	
		Miles.	Km.			Miles/h.	Km./h.
L. M. & S. Ry. + G. W. Ry.							
The Devonian	Bradford-Paignton.	322.8	519.5	10.30 a. m.	8.12	39.3	63.3
L. M. & S. Ry. + G. W. Ry. + S. Ry							
The Pines Express	Manchester L. Rd. Bournemouth W.	248.5	399.9	10.00 a. m.	6.20	39.2	63.1
	Liverpool (L. St.)-Bournemouth W.	253.8	412.4	9.40 a. m.	6.40	38.1	61.3
	Liverpool (L. St.)-Southampton.	277.0	445.8	R 10.12 a. m.	7.11	38.6	62.2
The Sunny South Express	Birkenhead-Brighton.	269.0	432.9	8.00 a. m.	7.27	33.6	54.1
	Do. -Hastings.	303.5	488.4	Do.	8.53	34.2	55.0
	Do. -Dover, Deal.	320.0	515.0	Do.	8.30	37.6	60.6
Great Western Ry.							
The Irish Mail	Paddingt.-Fishguard Hr.	261.3	420.5	7.55 p. m.	5.47	45.2	72.7
The Cambrian Coast Express	Paddington-Dovey Jn. Barmouth.	239.3	385.1	10.20 a. m.	6.13	38.5	62.0
	Do. -Aberystwith.	234.3	377.0	Do.	5.35	41.7	67.2

Both the « Devonian » and the « Pines Express » follow the western branch of the *L. M. S.*'s « fork ». Whereas the former continues along the *G. W.*'s main line, the second reaches Bournemouth by the *Somerset and Dorset Ry.*

The « Sunny South Express » connects Liverpool and Manchester with the southern seaside resorts, reaching the *Southern* system via Willesden Jn. and the *West London Extension Ry.* (1). (See Appendix, Chapter IX*bis*.)

(1) This train runs via Addison Rd. and Latchmere Jn. The Eastbourne portion runs on to Clapham Jn., and the Brighton one passes under the main line.

TABLE 57.

LIMITED NON PULLMAN TRAINS.

NAME OF TRAIN.	RUN FROM LONDON	Intermediate stops.	Distance		Time of departure.	Time spent.	Speed	
			Miles.	Km.			Miles/h.	Km./h.
Great Western Ry.								
The Cornish Riviera Ltd. Exp.	Padd.-Penzance.	5	305.3	491.3	10.30 a. m.	6.30	47.0	75.6
The Torbay Ltd. Express. . .	Padd.-Torquay	1	199.0	307.2	12.00 noon.	3.30	56.9	91.6
	and Dartmouth.	5	208.3	355.2	Do.	4.15	49.1	78.9
Southern Railway.								
The Atlantic Coast Ltd. Exp.	Wat.-Torrington.	6	225.8	363.3	10.35 a. m.	5.02	44.9	72.2
	Do. -Bude.	6	228.8	368.2	11.00 a. m.	5.21	44.0	70.8
	Do. -Padstow	10	260.0	418.4	10.45 a. m.	5.12	41.1	66.1
The Bournemouth Ltd. Exp. .	Wat.-Weymouth.	3	142.6	229.3	R 7 32 a. m.	3.08	45.6	73.4
The City Ltd. Express. . . .	L. Br.-Brighton.	0	81.3	130.9	5.00 p. m.	1.00	50.5	81.3

VII-2. — **Limited non Pullman trains.** — Both the southern Companies run « limited » trains, the two more important being the « Cornish Riviera Ltd. Express » and the « Atlantic Coast Ltd. Express » which the rival Companies run daily to Cornwall and Devonshire.

c) *Great Western named trains.* — The *G. W.* has a number of named trains, such as the « Flying Dutchman », the « Zulu », and later, the « Jubilee ». Next came the « Cornish Express », succeeded in turn, by the « Cornish Riviera Ltd. ».

The name « Flying Dutchman » is really a nickname bestowed after that of a well known horse, the winner of the 1849 Derby. Such was its popularity that it outvied the East Coast's « Flying Scotsman ».

An earlier train seems to have borne the name since 1849, but the better known one started in 1862, and has run without a break, ever since, though its timing has been altered many a time and it has lost its name in the process. It first took 9 h. 15 m. from Paddington to Penzance, but 2 hours 45 m. have been cut-off this timing (1).

(1) The « Flying Dutchman » originally left Paddington at 11.45 a. m. It was a broad-gauge train made up of 5 to 8 coaches weighing 130 to 180 tons. Each time it has been accelerated, the time of departure has been retarded instead of maintaining it, an advancing the arrival at the other end, as is the case with the « Flying Scotsman ».

It used to reach Exeter at 4.15 p. m., after stops at Didcot, Swindon, Bath, Bristol and Taunton, at an overall speed of 43 miles (69 km.) an hour. It stopped at all stations beyond and arrived at Plymouth at 7.25 p. m. — 3 h. 10 m. for 52.8 miles (85 km.) — and at Truro at 10.30 p. m. Whenever it has been speeded up, its run has been extended.

In 1864, 7 stops west of Exeter were cut out, and Plymouth was reached at 6.10 p. m., in 6 h. 30 m., at an overall speed of 38.4 miles (61.8 km.) per hour and the train was extended to Falmouth, where it arrived at 10.45 p. m.

And in June 1871, it was further extended to Penzance, which it reached at 10.04 p. m.

The Company then thought it might leave it well alone, so there was no further improvement until 1904 when the departure from Paddington was delayed until 12.25 p. m. In 1906 when the Castle Carey cut-off was opened, it was further retarded to 1 p. m., in 1911, to 1.30, and in 1921, to 2 p. m., the arrival in Penzance having remained unchanged at 10.10 p. m.

The « Zulu » was established in 1880 and owed its nick-name to the South African War.

When the new line through Bicester was opened, a 4.45 p. m. train was run under the name of the « Afgan » as far as Didcot and of « Northern Zulu » beyond.

In 1887, a « Jubilee » train was started. It was the first of the Plymouth expresses to carry 3rd-class passengers.

The « Cornish Express » made its bow to the public in June 1890, and was the first train to run non-stop past Bath, Taunton and Newton Abbot. Since March 1892, it has left Paddington at 10.15 a.m.; but it used to take 5 h. 35 m. to Plymouth and 8 h. 42 m. to Penzance. This train marks the passage from the old regime to the new. Previously 8-foot (2.45 m.) singles had taken all these broad gauge trains as far as Exeter or even Newton Abbot, and 2-4-0 or 4-4-0 locomotives beyond. On May 20th, 1892, the « Cornwall Express » ran for the last time under these conditions (locomotive « Great Britain ») and it became a standard-gauge train by next day.

The « Cornish Riviera Ltd. Express » is much better known, though it is but an outcome of the train we have just quoted. Since July 1st, 1904, it has run non-stop in four hours during the Summer months, from Paddington to Plymouth. This has remained the World's long-distance non-stop record for close on a quarter of a century.

During the Winter season, it carried three sets of slip coaches, each consisting of several carriages, which were slipped at Westbury (for Weymouth), at Taunton (for Minehead and Ilfracombe), and at Exeter. It then took seven minutes longer to Plymouth (1), but the 6 h. 30 m. for the journey to Penzance remained unchanged.

On Summer Saturdays, a relief train follows at a ten-minute interval with the Newquay and Falmouth sections and runs non-stop to Newquay, this being the longest *G. W.* run of the kind. But it takes as long to accomplish it as does the « Cornish Riviera Ltd. », although the latter stops at Plymouth and at Par to detach its own Newquay section.

On Mondays, the equipment comprises up to 15 coaches, weighing 510 tons and exceptionally 16, weighing 540 (2).

In spite of this, it is no rare occurrence for the train to run in from two to four parts. Each of the sections that usually go to make up the « Cornish Riviera » is then turned into a separate train, so that each place of destination receives an entire train instead of a few carriages only. Thus on Easter Thursday (April 13th last), the first and third parts ran to Penzance, the second, to Falmouth and the fourth, to Weymouth, Minehead and Ilfracombe.

In 1933, after completion of the Westbury and Frome by-pass lines, the timing of several *G. W.* expresses was smartened up and for the first time since 1904, the « Cornish Riviera » was booked from Paddington to Plymouth in under 4 hours. It fell short of them by 3 minutes only, but this may be improved upon in the near future.

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(1) Stoppages at Exeter and Par (for Newquay) have been inserted last Winter but the time of arrival has remained unchanged.

(2) These carriages are 60 feet (18.29 m.) long and 9 ft. 7 in. (2.92 m.) wide over body waist. They are amonsgt the widest to run in England, a souvenir of the time when the *G. W.* boasted the widest loading gauge in Europe.

14 of these carriages hold 496 passengers, 86 of whom find seats in the dining set at each sitting.

The « Torbay Ltd. Express » leaves the main line at Newton Abbot, having stopped at Exeter only, save on Saturdays, when it runs non-stop to Newton Abbot. It serves the Torbay seaside resorts such as Torquay and Paignton, which is also the terminal of the « Pines Express » from Bradford (*L. M. S.*).

d) **The Southern Ry.'s Ltd. trains.** — This Company also has its named expresses :

On the Plymouth line, the « Atlantic Coast Ltd. Express »,

On the Weymouth line : the « Bournemouth Ltd. »,

On the Brighton line : the « City Ltd. »,

And on the Dover and Ramsgate lines, quite a number, dating from very early days.

The « Atlantic Coast Ltd. » is the Company's crack train, competing for the West of England traffic, with the *G. W.*'s « Cornish Riviera Ltd. ».

In Summer, it is booked in two parts on weekdays and in three, on Saturdays, which follow each other at quarter of an hour's intervals to Ilfracombe, Bude and Padstow, thus enabling them to be duplicated if necessary.

The « Bournemouth Ltd. » is a Bournemouth train which runs up to town in the morning and down in the evening, as does the « City Ltd. » from Brighton to London Bridge and back. The « Bournemouth Belle » and the « Southern Belle » Pullman trains run along the same lines, but the other way about, that is to say from London and back.

Three six-coach sets, including a Pullman car, have been built for the electrified « City Ltd. ». Each of them weighs 263 tons and contains 104 third and 126 first-class seats, besides 16 thirds and 12 firsts in the Pullman (1).

None of the *Southern*'s own London and Dover or Ramsgate trains now bears a distinguishing name, though one of its older trains was probably the first to have done so (2).

The earliest was the « Granville special express » which the proprietor of the Granville Hotel, got the *South Eastern* to run in 1876 and whose financial results he guaranteed. Of course, the rival *L. C. and D. Ry.* immediately started a « Westgate-on-Sea and Granville Special Express » train (3).

After their disappearance, a « Club Train » was run by the *International Sleeping Car Co.* in 1889, from London to Dover, in connection with similar Continental trains, but it was unsuccesful.

(1) Each of the end brake thirds weighs 59 tons and has two open third saloons. The Pullman weighs 43 tons, each of the three first class carriages, 34.

(2) For many a year, the designation « Flying Scotsman » was unofficial and the « Flying Dutchman »'s always remained so.

(3) The names « Westgate-on-Sea » was added by the *Chatham Co.* at the request of a certain Mr. Edmund F. Davis, who got the Company to insert this extra stop and gave some sort of guarantee in exchange.

The « Kent Coast Express » ran from Margate to Cannon St. since 1883 (dep., 7.55; arrival, 10.15 a.m.). It was the ancestor of a numerous progeny of « coastal » trains, such as the « Lothian Coast Express », the « Fifeshire Coast Express », the « Cornish Riviera » and on the other side of the Channel, the « Côte d'Emeraude », the « Côte Basque », the « Côte d'Argent » and the « Riviera » expresses.

The « Tidal Express ». — Before Boulogne's harbour improvements, the London and Folkestone connecting train's timings varied with tide, as do the Southampton train's connections with the Saint-Malo boats. The name « Tidal Express » actually remained to the train until 1899, when the *S. E.* and *L. C. D. Co.* came to their agreement, though since a long time, there had no longer been anything tidal about it.

Two other trains, the « Cliftonville Express » and the « Thanet Express », which both ran from Victoria to Ramsgate (1), by the Chatham route, disappeared when the War broke out.

After the Armistice, « Golden Arrow » trains were run on both sides of the Channel, but as they are all-Pullman trains, they will be dealt with in the next chapter.

VII-3. — **Slip carriages.** — Every year sees a decrease in importance of these services, the number of which, in 1914 and 1931, we reproduce from *The Railway Year Book*.

TABLE 58.

NUMBER OF SLIP CARRIAGES IN 1914 AND 1931.

RAILWAY COMPANY.	In 1914.	In 1931.
Great Western Ry.	70	35
Southern Ry.	29	2
London Midland and Scottish Ry.	44	0
London and North Eastern Ry.	19	4
Great Northern Ry. (Ireland)	0	2
Great Southern Rys. (Ireland)	7	1
Belfast and County Down Ry. (Ireland)	8	0
	170	44

TABLE 59.

SLIP CARRIAGES.

RUNS OF A FEW SLIP CARRIAGES.	Distance		Time of departure.	Time spent.	Speed	
	Miles.	Km.			Miles/h.	Km./h.
Paddington and Bath	106.9	172.0	1.15 p. m.	1.42	62.9	101.2
Do. and Didcot	53.3	85.8	11.15 a. m.	0.57	54.9	88 3
(Paddington) Swindon and Chippenham	16.8	27.0	5.54 p. m.	0.17	59.3	95.4
(Do.) Taunton and Westbury	41.3	76.0	10.45 a. m.	0.52	54.6	87.9
(Do.) High Wycombe and Banbury	41.0	66.0	9.43 a. m.	0.41	60.0	96 6
(Do.) Do. and Leamington.	60.8	97 9	9.43 a. m.	1.00	60.8	97.9
(Do.) Reading and Didcot	17.3	27.9	R 9.17 a. m.	0.22	47.2	75.9
(Do.) Do. and Taunton	106.9	168.9	R 10.45 a. m.	1.43	62.8	101.3
(Do.) Bristol and Swindon	41.0	66.0	R 5.15 p. m.	0 50	49 2	79.2
(Do.) Do. and Reading	82.3	132.5	R 5.15 p. m.	1.24	58.8	94.7

(1) The « Cliftonville Express » left Victoria at 9.50 a. m. and ran non-stop over the 79.5 miles (127.9 km.) to Ramsgate, in 1 h. 50 m.
The « Thanet Express » left at 10.15 a. m. and took 2 h. 2 m., but it stopped at Chatham.

A few minutes are saved each time a slip instead of a stop is made, but this is only the case on down trips. In certain instances, the slipped carriages then run on a stopping schedule to some place where they can be conveniently picked up for the return journey.

Table 59 quotes some examples of slips on the *G. W.*, the Company that has remained the most faithful to them. Several trains have two slip sets and the « Cornish Riviera » as previously stated, has three.

This is also the case with the French *State Rys'*. new Havre « rapide ». It is rather odd that this administration should be reintroducing slip carriages precisely at the time they are going out of favour on the British railways.

VII-4. — **Newspaper expresses** constitute a special class of traffic which should rank with passenger expresses, as they are timed to run at similar speeds, with trains made up of similar stock.

The longest run, in the British Isles, is the Saturday night *L. M. and S.* down 8.20 p. m., from Euston to Motherwell (where it divides) and Glasgow, in 8 hours and 34 minutes, with five intermediate stops (1) which account for 32 minutes, thus leaving 8 hours 2 minutes running time. The other branch runs on to Aviemore and Inverness (2), which it reaches in 12 3/4 h.; it then continues on a much slower schedule to Lairg, 635 1/2 miles away. During the Summer, the locomotive that has taken it there returns light over a distance of 66 3/4 m. (107.8 km.) in 2 h. 20 m.

The East Coast Saturday 11.5 p. m. newspaper express stops only 3 times between King's Cross and Newcastle (3) and takes but 20 minutes more than the « Night Scotsman » for the trip, part of the time having been spent in long stops at the stations.

Since 1930, the *Southern Ry.* has been running a daily 13 to 15-van newspaper express from Waterloo to Plymouth. The train's departure time (1.30 a. m.) has remained unaltered, but after having been slowed down, it is again timed to cover the entire distance in 1 h. 49 m. This entails some hard work as 94 minutes only are awarded over the difficult 88-mile stretch from Salisbury to Exeter, which is accomplished at the rate of 56.2 miles (90.4 km.) an hour (4).

Many newspaper or postal trains, which run in the small hours of the morning, now have a small amount of passenger accommodation.

CHAPTER VIII.

Pullman, Sleeping, Restaurant and Drawing Room Services.

All sleeping cars are now provided by the Railway Companies, but this is not the case for the luncheon and dining services, many of which are in the hands of the *Pullman Co.* This is clearly shown in table 60 which applies to the year 1932 and is compiled from the *Universal Directory of Railway Officials and Railway Year Book.*

Pullman first came to England in 1873 and, soon after, supplied the *Midland Ry.* with 18 cars, most of which were sleep-

(1) At Crewe, Wigan, Carlisle and Carstairs, and Motherwell at 4.54 a. m.

(2) Intermediate stops take place at Larbert, Stirling, Gleneagles, Perth, Pithlocrie, Kingussie and Aviemore.

(3) Stops occur at Peterboro' (4 minutes), York, (8 minutes), Darlington and Durham.

(4) This in spite of a long 1 in 80 (12.5 mm. per m.) bank and the short stretch of 1 in 70 (13.3 mm. per m.) on Seaton Bank.

TABLE 60.

RESTAURANT CARS.

Railway Companies' services.			Pullman Co.			Totals.
	Rest. cars.	Buffet cars.	Rest. cars.	Saloons.	Pullman trains.	
GREAT BRITAIN.						
G. W. Ry.	93	4	...	...	...	110
S. Ry.	66	...	...	112	8	195
Metropolitan Ry.	...	...	...	10	...	10
L. M. and S Ry	192	4	48	2	...	264
L. and N. E. Ry.	134	8 (1)	6	6 (2)	8	168
IRELAND.						
Great Southern Ry	6	12	...	...	..	18
Great Northern Ry	10	...	...	6	..	16
Northern Counties Committee.	...	8	...	..	...	8
Totals	501	36	54	136	16	737

(1) Light refreshments are served in sleeping-cars.
(2) These cars run in the same trains as other dining cars and are not included in the totals.

TABLE 61.

ALL-PULLMAN TRAINS.

NAME OF PULLMAN TRAIN.	Running between	Distance		Time of departure.	Time spent.	Intermediate stops.
		Miles.	Km.			
Southern Railway.						
The Bournemouth Belle	Waterloo-Bournemouth W.	111.5	179.4	10.30 a. m.	2.22	2
The Southern Belle.	Victoria-Brighton.	50.8	81.8	11.00 a. m.	1.00	0
Eastbourne Sunday Ltd.	Do. -Eastbourne.	65.8	105.9	10.45 a. m.	1.20	0
The Golden Arrow	Do. -Dover Marine.	80.0	128.7	11.00 a. m.	1.35	0
The Thanet Pullman Ltd.	Do. -Ramsgate.	79.5	127.9	9.04 a. m.	1.54	2
L. and N. E. Ry.						
The Eastern Belle Ltd.	Liverpool St.-Clacton-on-Sea.	70.8	114.0	9.55 a. m.	1.30	0
The Queen of Scots	King's Cross-Glasgow.	453.6	730.0	11.20 a. m.	9.00	6
The West Riding Pullman	King's Cr.-Wakefield-Halifax.	202.8	326.4	4.45 p. m.	4.12	4
	Do. Do. -Newcastle.	280.8	451.9	Do.	5.38	4
The Harrogate Sunday Pullman	Do. -Leeds-Harrogate.	202.8	326.4	10.00 a. m.	4.00	2
	Do. Do. -Bradford.	195.3	314.1	Do.	3.52	1
Great Western Ry.						
The Torquay Pullman Ltd.	*Paddington-Paignton.*	201.0	323.5	*11.00* a. m.	*3.50*	2

ers. The drawing room cars were sold outright, and the sleeping cars ran on a contract basis, which expired in 1888. All these cars had been built in America and put together in England. They started their career in 1874, some of them in an « All-Pullman London and Bradford Express », the balance in day trains.

They were the first bogie carriages in the Country, but the very next year, the *Midland* built 50 similar 6-axle bogie coaches and the *G. W.*, its first bogie sleeping cars in 1881.

Since then, Pullman services have developped so rapidly that a British *Pullman Co.* of which Sir Davidson (then Mr.) Dalziel secured control in 1908, was formed. Since then, Pullmans have no longer been built abroad. The Company now operates both all-Pullman trains and separate Pullman saloon, observation and restaurant car services.

The make-up of the sets varies, of course, but not to a large degree. All these trains are 1st and 3rd, save the « Golden Arrow », which is first only.

TABLE 62.

WEIGHT OF PULLMAN TRAINS.

NAME OF TRAIN.	Usual formation.		Exceptional formation.	
	Number of carriages.	Weight. (tons)	Number of carriages.	Weight. (tons)
The Bournemouth Belle	10	408	11	450
The Southern Belle	5	248	10	496
The Eastern Belle Ltd.	7	277	8	319
The Queen of Scots	7	285	8	325
The West Riding Pullman	7	301	8	345
The Golden Arrow			11	450

VIII-1. — Pullman trains. — a) *Southern Ry. Pullman trains.* — The oldest of these trains, the « Southern Belle », was inaugurated in 1875 by the *L. B. S. C.* under the name of « The Pullman Ltd. Express », and was made up of five Derby assembled cars, comprising a Pullman saloon, a parlor-car, a buffet-car, a smoking-car and a luggage van. The set was electrically lighted by Edison lamps and Taure batteries. It ran as a Sunday all-Pullman train between Victoria and Brighton and on weekdays, when it was called the « Little Pullman », instead of the « Sabbath Breaker », two or three ordinary coaches and a luggage van were substituted to one of the Pullman cars.

These early cars were 58 feet (17.68 m.) long and had been so carefully built and put together that they lasted for years. In fact, some of them were converted into third-class Pullmans in 1915, and a few of them are still in service.

As for the early « All-Pullman » train, its name was changed after a time and the « Southern Belle » succeeded to it on November 1st, 1908.

The original four-car set (without counting the van), became a 9-car set, with a couple of extra cars, when needed.

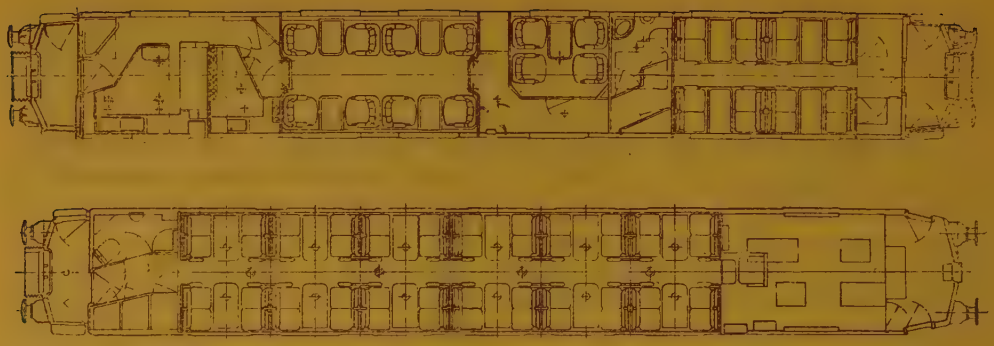

Fig. 15 (*). — Pullman cars of the electrified Brighton line.
a) 1st and 3rd composite. — *b*) 3rd and luggage compartment (1).

These sets had 368 seats for first and third-class passengers and, since 1910, they performed daily two return journeys between Victoria and Brighton. The line is an easy one, save for a 1 in 64 (14 mm. per m.) bank out of London (2).

The entire Brighton and Hove lines are now electrified, but the service has not been speeded up yet. Owing to present depressed conditions, the Pullman sets are made up to 5 cars only, but there are three double journeys instead of two. The former cars have been retained on the same railway and been included in steam-hauled trains.

38 new ones including 23 cars for various services and three sets for the « Southern Belle » have been built (1). They are larger than the older cars and each set has a capacity of 40 first and 152 third-class passengers (fig. 15).

A third-class Ltd. Pullman express was run in 1922, but has since been discontinued.

The « Bournemouth Belle » was started on July 5th, 1931, and was then a 7-car, 384-ton train, with seating capacity for 74 first and 240 third-class passengers in 3 plus 4 cars. There are kitchens in four cars only, and half the set is cut out in Southampton.

The Golden Arrow » is the British portion running between Dover Marine and Victoria of the Paris and London « Golden Arrow » service. This idea is not new, as the *Sleeping Car Co.* had tried it in 1889 (the « Club Train ») but this time, it has been successful. The train used to be formed of 8 to 10 cars and overflow Pullman cars, often up to 5 in number, were included in the *Southern* relief trains. It weighed from 450 to 460 tons and was hauled by 140-ton Nel-

(*) Reproduced from *The Locomotive*.

(1) *Principal dimensions.*	*Southern Belle.*		*Bournemouth Belle.*	
Overall length	66' 8" 3/4	20.34 m.	—	
Length including vestibules	66'	20.12 m.	65' 4"	19.91 m.
» over body	65'	19.81 m.	57' 1" 1/2	17.41 m.
Height from rail to top of roof	12' 5"	3.79 m.	12' 5"	3.78 m.
Width at body waist	8' 11" 1/2	2.61 m.	8' 5"	2.57 m.
Distance of bogie axles	47'	14.33 m.	—	
Bogie wheelbase	8'	2.44 m.	—	
Wheel diameter	3' 6"	1.07 m.	—	

(2) This bank is situated between Victoria and Grosvenor Rd.

son locomotives. But owing to the considerable fall off in Continental traffic, the « Golden Arrow » is no longer an all-Pullman train and the « Golden Arrow » service now consists in some four or five Pullman cars included in the ordinary boat trains. The *Southern*'s London suburban traffic is so heavy that, when late, the « Golden Arrow » follows another route to Victoria.

Among the Sunday Pullmans, the « Thanet Pullman » runs in three parts from Victoria to Ramsgate, Margate and Broadstairs, starting from Victoria at 9.04, 9.50 and 10.00 a. m., and returning at 5.10, 6.25 and 6.40 p.m.

The « Eastbourne Sunday Ltd. » is a revival of the pre-War « Eastbourne Ltd. », a 90-minute non-stop train, that used to slip a car at Haywards Heath for Worthing.

b) *Great Western Pullman trains.* — The only one of these trains, the « Torquay Pullman Ltd. » was a very temporary affair and ran on the *G. W. Ry.* (1) between June, 1929, and September, 1930, only. The cars were then transferred to the Southampton boat trains. No other Pullmans now work on the *G. W.* that runs its own « de luxe » cars in its Plymouth boat trains.

c) **The L. N. E. Pullman trains.** — The « Clacton-on-Sea Pullman », now the « Eastern Belle » runs on Sundays between Liverpool Street and Clacton-on-Sea and on weekdays, at cheaper rates, to various

TABLE 63.

THE EASTERN BELLE'S RUNS.

FROM LIVERPOOL STREET TO	Distance		Time of departure.	Time spent. (2)	Speed	
	Miles	Km.			Miles/h.	Km /h.
Clacton-on-Sea	70.8	114.0	9.55 a. m.	1.37	43.9	69 2
Felixtowe Town	128.0	206.0	R 7.35 p. m.	2.15	56.9	91.5
Wroxam (N. Walsham and Cromer)	124.0	199.5	11.00 a. m.	2 55	42.5	68.4
Yarmouth S. T.	121.8	196.0	11.00 a. m.	2.55	41 7	67.1
Thorpeness (Aldeburgh + 7')	139.5	224.5	11.50 a. m.	2.43	51.4	82.7
Skegness	121.8	212.1	11.05 a. m.	3.33	35.8	57.6
Heacham (Hunstanton + 5').	111.5	179.4	11.05 a m.	2.50	39.4	63.4
W. Runton (Sheringham + 4')	142.0	228.5	11.00 a. m.	3.38	39.2	63.1
Lowestoft Central.	117.8	189.6	11.00 a. m.	2.50	41 6	67.0
Dovercourt Bay (Harwich + 3')	70.3	113 2	11.50 a. m.	1.50	38.4	61.8
Frinton-on-Sea (Walton-on-the-Naze + 5').	70.3	113.2	11.50 a. m.	1.45	30.6	49.3

(1) Its first stop, Newton Abbot, was made after a 3 h. 25 m. run.

(2) Most of these runs have been speeded up as under :

Felixtowe	2 h. 00	Cromer	2 h. 57
Yarmouth	2 h. 35	Aldeburgh	2 h. 15
Skegness	R. 3 h. 10	Hunstanton	2 h. 40
Sheringham	3 h. 12	Lowestoft	2 h. 30

other East Coast resorts. In these cases, besides the terminus of the run, it usually runs non-stop to another place, just before getting there. We quote this latter run in table 63 and have added in parenthesis the name of further resorts with the number of extra minutes it takes the « Eastern Belle » to get there.

The « Queen of Scots » between King's Cross and Newcastle, was inaugurated in July 1923. It ran non-stop to Leeds, off the main line (1) which it rejoined at Northallerton, after having stopped at Bradford and Harrogate on the way.

In July 1925, it was extended to Edinburgh and at the end of the Summer season, ran non-stop to Harrogate (via Church Fenton) (1) and continued beyond, as previously.

It was given its present name in May 1929, when it was again run via Leeds and further extended to Glasgow.

The « West Riding Pullman ». — Owing to there being a number of important places to the West of the main line, it is difficult to choose which of them are the most suitable to run to, and the Company has felt its way and several times altered the trains' runs before definitely fixing them as they are.

We might incidentally recall that the first English Pullman train was the *Midland*'s « St. Pancras and Bradford Express », and that these places are still served by the same line's (non Pullman) « Yorkshireman ».

As the « Harrogate Pullman », the train we are considering was inaugurated in 1923 between King's Cross and Harrogate, but in June 1924 it became the « Sheffield Express » which was extended to Manchester from the 1925 Summer. After the season, it became the « West Riding Pullman » running non-stop to Leeds and finishing at Bradford, thus duplicating the « Queen of Scots », the Leeds stop of which was cut out. These two trains cannot really be considered independently, as they both cater for the West Yorkshire traffic.

Since September 1926, the « West Riding Pullman » is made up of two portions which separate at Wakefield; the first of them runs on to Bradford and Halifax (Old), and the second, to Leeds and Harrogate with an extension to Newcastle, since 1927.

On Sundays, its place is taken by the « Harrogate Sunday Pullman », non-stop to Leeds, where division takes place so as to serve Harrogate and Bradford.

VIII-2. — **Pullman car services.** — Differing in that from continental practice, the British railways have their own sleeping cars and also many of their luncheon or dining cars, which they run in all express and most excursion trains, but in spite of this, the *Pullman Co.* has managed to build up a large business. One realises how difficult a matter this has been, when noticing the competition it is up against. It is even now possible to

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(1) The distance by non-stop trains is :
198 miles (318.7 km.) from King's Cross to Harrogate;
186 miles (299.4 km.) Do. to Leeds.
The longest tunnel of the *L. N. E. Ry.* (Branhope tunnel, 2 miles 241 yards = 3 439 m.) is situated on the Leeds-Harrogate 18 1/4-mile (29.4 km.) section.

lunch or dine, between York and Darlington, either in cars belonging to the *Pullman Co.*, or in cars belonging to the *L. N. E.*, who owns the line, or in through cars belonging to the *L. M. S.* to the *G. W.* and even to the *Southern* Railways !

For its British and Irish services, the *Pullman Co.* now owns :

112 first-class Pullmans;
40 first and third composites;
73 third-class Pullmans;
1 observation car;
32 restaurant cars;
2 kitchen cars.

The greater part of this stock is earmarked for service on one or other of the Railway Companies and provided with suitable drawgear, gangways, safety devices, etc. But there is also a common « pool » which is called upon for special services such as the *Southern* and *L. N. E.* race specials, the Bournville or Bristol (*G. W.*) and Brighton (*S.*) excursion trains and so on. This is where the kitchen cars come in as well.

Besides its usual cars, the *Pullman Co.* runs an observation car in Scotland and restaurant cars on the continental principle, where passengers of any class may partake without any extra fare of meals or refreshments.

As a rule, the *Pullman Co.*'s contracts with the Railway Companies call for no payment on either side, the former providing the rolling stock and staff and the latter, haulage. Upkeep is charged on a 50 % basis. The new 30-year contract with the *Southern Ry.*, which is the largest of the Company's customers, provides for the running of 38 new cars on the electrified lines.

Pullman sleeping cars. — The *Midland Ry.* ran Pullman sleeping cars between St. Pancras and Bradford since June 1st, 1874, and the service was extended to Liverpool on April 1st, 1875. They were « open » American pattern cars, which type has gradually died out, the last open sleepers being built in 1900, with a few ordinary third-class compartments thrown in.

In 1876, as soon as the *Midland*'s Scottish extension was completed, this Company included Pullman sleepers in its night trains so as to compete with the two other lines who had each run their own since 1873.

As a matter of fact, the *Great Northern* did run some Pullman sleepers in 1879, but soon gave them up, and the *Highland*'s Glasgow and Inverness Pullman sleepers were superseded by its own cars in 1906.

In the meantime, the *Midland Ry.* had bought its ordinary Pullman cars outright, and its sleepers in 1888, when the original contract expired. The *Great Northern*'s Pullman sleepers were sold to the Italian *Meridionali* Railways.

Ordinary Pullman cars.— In the meantime, there was a growing demand for buffet-parlor cars which appeared on several of the British Ry. Companies. Third-class Pullmans were first introduced on the *L. B. S. C.* in 1915.

Second-class Pullmans were run on *G. E.* and *L. B. S. C.* boat trains (Harwich and Newhaven services) in 1922, but were soon withdrawn and converted into thirds.

The *L. S. W.* ran Pullman car trains from Waterloo to Bournemouth from 1890 to 1913, but the cars were superseded by the Railway Company's and found a new home with *L. B. S. C.*

The *South Eastern* introduced Pullmans in 1910 and its successful services

culminated in the post-War « Golden Arrow » service.

On the *Great Eastern*, Pullman services were maintained between 1923 and 1926, but they were not sufficiently patronized and are now restricted to the Harwich and Clacton-on-Sea trains only.

In 1929, at the same time as it started the « Torquay Pullman Express », the *G. W.* introduced Pullman cars into its transatlantic boat trains, but they were soon withdrawn and transferred to the *Southern*'s, where they have run with growing favour, since January 2nd, 1931.

Pullman cars have been most popular with the *Southern Ry.*, originally on the former *L. B. S. C.*, later on the *S. E.* as well. All services, with the exception of the Littlehampton and Portsmouth trains which have only third-class cars and the Dover and Folkestone trains, which have only 1st-class cars, cater both for first and third-class passengers.

There are now 81 weekday services (1), more on Saturdays and fewer on Sundays, besides some ten services in the Dover, Folkestone and Newhaven, and four in the Harwich Continental expresses.

Those formerly included in the former *Midland*'s St. Pancras and Tilbury boat trains have been transferred to Folkestone, when the boats changed over to the latter port.

There is a rather unexpected Pullman car service on the *Metropolitan Ry.*, which is run in 1 h. 33 m., including numerous stops, over the 38.5 miles (61 km.) of suburban line from Aldgate or Baker St. to Chorley Wood, Amersham and Aylesbury.

Pullman restaurant-car services. — In June 1914, the *Caledonian Ry.* introduced Pullman cars between Glasgow and Edinburgh, but soon substituted Pullman restaurant-cars on the continental plan, where first and third-class passengers paid no extra fare while taking meals.

Other services of the kind were started in 1922 and 1923 on the *Highland* and *Glasgow* and *South Western Railways*. All three Companies now form part of the *L. M. S.* (1), and the *L. N. E.* has followed suit with similar Pullman restaurant car services (2).

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(1) From Victoria to Portsmouth (7), Bognor Regis (4), Littlehampton (1), Brighton (14), Lewes (1), Hove and West Worthing (16), Eastbourne (2), Hastings (1).

From Charing Cross or Cannon Street to Hastings (10), and Ramsgate (7). Also to Dover Priory (1), Deal (1) and Sandwich (5).

From Victoria or Cannon Street to Herne Bay and Ramsgate (10).

In the Victoria boat trains : (2) to Newhaven, (3) to Folkestone and (5) to Dover Marine.

(1) The *L. M. S.* services are those from Glasgow or Perth to Aviemore (2), one of them being included in the down « Royal Highlander »;

From Carlisle to Glasgow or Aberdeen (2) on Saturdays;

From Stirling to Oban (2) and from Carlisle to Glasgow or Aberdeen (4);

(2) On the *L. N. E.*, the following services are run :

From Edinburgh to Glasgow (2) and Perth (2);

From Glasgow to Stranraer (2), Beattock and Carlisle (1);

Glasgow to Oban (4), besides an observation car which is the only one running in the British Isles;

Stirling to Oban (1);

Glasgow to Edinburgh (9);

VII-3. — **The International Sleeping Car Co.**'s only English service existed in 1889, during the Paris Exhibition. This was a « Club Train » run between London and Dover and, on the other side of the Channel, between Calais and Paris with a Calais and Brussels connection.

Each set was made up of 5-bogie carriages and luggage van, the latter with a drawing room section (1), besides a 4-wheeled guard's van. The French train had a restaurant car as well. But partly owing to insufficient advertising, the trains lacked patronage and were soon taken off.

The former cars were 51.5 feet (15.70 m.) long over body and weighed 28 tons (28.5 metr. t.). The restaurant was 51.2 feet (18.63 m.) long overall, and 51.8 feet (15.79 m.) over body, and was a little lighter (26 tons).

All cars ran on two four-wheeled bogies, spaced 39 feet (11.90 m.) between centres and having an 8.2-foot (2.50 m.) wheelbase.

VIII-4. — **The Railway Companies' sleeping, restaurant and drawing room cars.** — British railways build their own cars but are handicapped by their very restricted loading gauge. Figure 16, which reproduces the proposed standard British, Continental and American gauges, and an example of a British gauge (the *Great Western*'s), shows this clearly.

The first corridor train was built by the *G. W.* in 1892, and this type of railway coach spread so quickly to other Companies that on the *G. C.*'s opening its London extension, it was able to advertise « all corridor buffet-car expresses ».

(1) The drawing-room cars had two saloons with accommodation for 18 passengers and an 8-passenger coupé; the dining car seated 24 passengers in two open saloons.

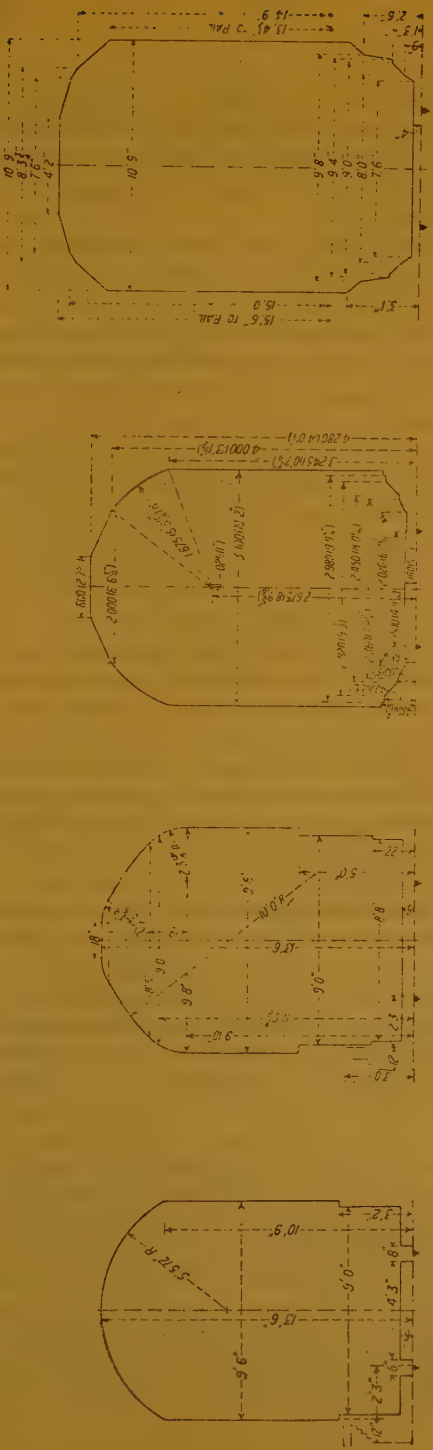
Proposed American loading gauge.
Proposed standard Continental gauge.
Great Western Ry. loading gauge.
Proposed standard British loading gauge.

Fig. 16. — British, Continental and American proposed standard loading gauges (*), 4 ft. 8 1/2 in track.[1]

(*) This illustration is reproduced from the *Universal Directory of Railway Officials and Railway Year Book*, 1933-34 Edition.

Since then, not only have the Railway Companies built complete sets for their London expresses, but they have also done so for their provincial and even excursion trains (1).

Observation cars were introduced on the *Cambrian Ry.* en 1915.

Though many Companies have run what amounts to « de luxe » drawing room cars, extra fares have hardly ever to be charged, save on the *G. W.*'s transatlantic specials, where an extra 10 sh. is collected for their occupation between Plymouth and Paddington. These splendid vehicles, which weigh 35 tons, have a large saloon for 17 passengers, a smaller one for 8, and a coupé for 4. They are 60 feet (18.29 m.) long, and 9 ft. 7 in. (2.92 m.) wide over body waist and 9 feet (2.74 m.) inside. The « Cornish Riviera »'s 10 feet (3.05 m.) wide carriages and some former Lancashire and Yorkshire carriages are alone wider.

The unusually large number of sleepers and diners owned by the Railway Companies is due to the fact that they run in specials and excursion trains besides the ordinary trains.

Six-wheeled bogies, conducive to smooth running, have been used to a greater extent under British sleeping and restaurant cars than on Continental railways. Their weight is their principal drawback, *North British* restaurant cars weighing over 50 tons a piece (2); *L. M. S.* twelve-wheeled sleepers are somewhat lighter but still turn the scale at 45 tons, whilst the usual run of 8-wheeled sleeping or dining cars weigh from 41 to 44 (3).

Sleeping cars. — The earliest British sleeping car was the old *London and Birmingham*'s 1838 rudimentary « bed carriage ». Padded boards were laid at night between opposite seats and this simple device was the embryo of our modern refined « wagons-lits ».

Sleeping cars as we understand them, were three-axle coaches first introduced on the East Coast in 1873 and a few months later — of course — on the West Coast as well. They had compartments copied from the « Mann's Boudoir Sleeping Cars » then running from Ostend to Central Europe, and which the *Great Western* also introduced in 1877.

In the meantime, the American « open » Pullman sleeper had been running on the *Midland* since June 1st, 1874.

These new vehicles had thus appeared in quick succession on each of the Anglo-Scottish lines whose rivalry was, once again, to cause railway progress, as it frequently did before and since.

We will go over the Railway Companies' sleeping cars services here, having devoted Paragraph VIII-2 to the *Pullman Company*'s.

Most of the data we have gathered have been kindly supplied by the Railway Companies; some further information has been gathered from an interesting article contributed by Mr. C. Hamilton Ellis to the *Railway Magazine*, and from the *International Sleeping Car Co.*

(1) To quote a recent example, in April 1931, the *L. N. E.* ran newly built eight-car sets, including a restaurant between Leeds and Glasgow. They had a seating capacity of 66 first-class and 250 third-class passengers.

(2) Composite 1st and 3rd restaurant and kitchen cars weigh 52 t. 16 cwts. 1st and kitchen cars, 51 tons and partly open, partly restaurant cars, 47 tons.

All these cars are 66 ft. 1 in. (20.15 m.) long.

(3) *L. N. E.* restaurant and electrically-equipped kitchen cars weigh 44 tons, as do *L. M. S.* cars and the *G. W.* pantry and kitchen cars of its limited trains.

a) *East and West Coast sleeping cars.* — The *G. N.* (1) and the contemporaneous *N. B.* sleeping cars were simultaneously run from King's Cross and back, and from Glasgow and back. The former had but two lavatories, the latter, one in each compartment. A 10-sh. extra fare was charged.

The West Coast Route's first sleepers ran from October 1st, 1873. They were 33 feet (10.06 m.) long, and contained 12 berths, 8 of them for gentlemen and 4 for ladies. The *L. N. W.* soon included sleeping cars in its Liverpool trains and in the « Irish Mail » to Holyhead. Five shillings a night only was charged for their use.

It then built longer cars of 42 feet (12.80 m.) instead of 33, which obliged it to place four axles under the cars, the first to be so treated. But the axles were not grouped in bogies, the end ones simply having more lateral play than the others. These cars had 2 two-berth and 2 four-berth compartments, but they were shaky, especially in the upper berths, which were soon taken out.

In 1893, the East Coast Route ran its first bogie sleeping car with 6 single compartments and 2 double ones. That same year, the West Coast Route exhibited, at the Chicago Exhibition, a sleeper containing 2 two-berth and 2 four-berth compartments. It built its first bogie sleeping cars in 1902 only.

b) *Midland Ry.'s sleeping cars.* — Pullman open American sleepers running on two three-axle bogies, were purchased by the Company in 1888 at the expiration of the original 1873 contract, and the open type was given up after the building of the 1900 vehicles which contained 4 single compartments besides the usual open bed chamber.

c) The *Highland Ry*'s. sleeping cars superseded their former Pullmans in 1907, on the Glasgow-Inverness service. Besides sleeping compartments, they had, as on many of the West Coast sleepers, a few ordinary 3rd-class compartments.

d) The earliest *Great Western*'s sleepers were broad gauge cars, which ran in 1877 between Paddington and Penzance. Four years later, this Company ran the first British-built bogie sleeping cars, but though the 7-foot gauge was still in use, they were provided with standard-gauge bodies so as to allow of easy conversion when the time came. They contained 4 two-berth compartments, with longitudinal berths, besides transverse berths in the end and staff compartments; there were no upper berths.

The Company's earliest standard sleeping cars were built in 1890 (2), and others

(1) In 1876, the *G. N.* had three sleeping cars, all of which were then transferred to the *East Coast Joint Stock.*

(2) Principal dimensions of early *G. W.* sleeping cars.

Year of construction	1877		1893		1881		1890	
Number of berths	11		8		10		14	
Do. lavatories	2				3		—	
Width, inside	10'	3.05 m.	—					
Do. over body	10' 6"	3.20 m.	—		8' 6"	2.59 m.	8' 6"	2.59 m.
Length over body	29'	8.86 m.	44'	13.41 m.	—	—	9'	2.74 m.
Do. of bed	6'	1.83 m.	6' 4"	1.93 m.	46' 6"	14.17 m.	50'	15.24 m.
Height, floor to top of car.	8' 10"	2.69 m.	—		—	—	—	—
Height, rail to top of car	—	—	11' 7"	3.53 m.	8' 7"	2.62 m.	8' 7"	2.62 m.
Number of axles	3		2 + 2		12' 6"	3.81 m.	12' 6"	3.81 m.
Total wheelbase	—	—	36'	10.97 m.	—		—	
Bogie wheelbase	—	—	8'	2.44 m.	8' 6"	2.59 m.	—	—
Distance, bogie centres	—	—	28'	8.53 m.	—	—	—	—

have followed from time to time. Besides this, the *G. W.* bought from the *L. S. W.* the special sleepers the latter Company had built in 1908 for its Devonport and Waterloo Ocean specials, and which had real beds instead of berths (1) an improvement which the public hardly appreciated.

e) Recent sleeping cars have undergone the same modernisation in Great Britain as on the Continent. The over-decoration of former years has been done away with and the hygiene and sanitary arrangements, much improved.

The first articulated sleeping cars were built by Mr. Gresley for the East Coast in 1922 and third-class sleepers have appeared since the grouping, in 1928.

The *L. N. E.* was the first to provide hot and cold shower baths in sleeping cars, and the *G. W.*, first to build third-class sleepers which were not convertible into day coaches, the *L. N. E.* (fig. 17)

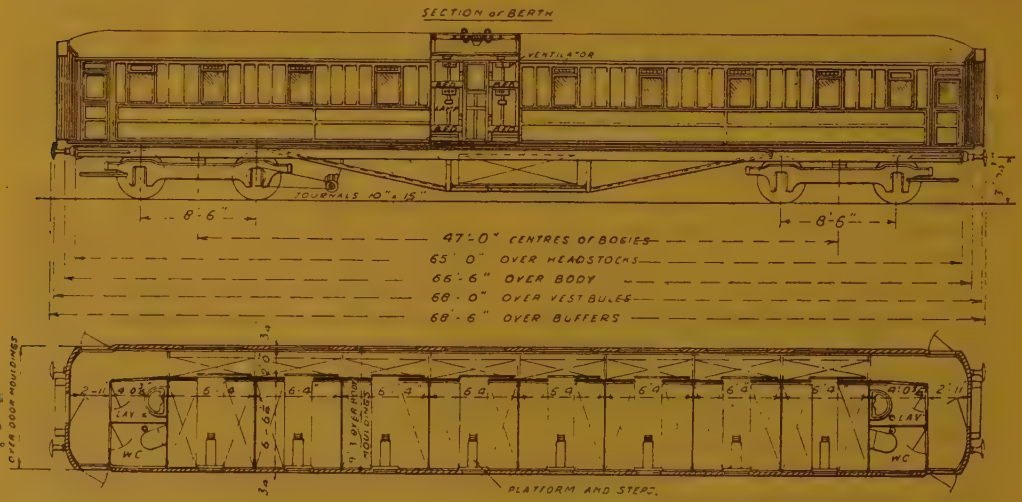

Fig. 17. — New non convertible L. N. E. R. third-class sleeping car (*).

and *L. M. S.* (2) both following suit. Each compartment has two lower and two upper berths, and there are lavatories at either end. The *L. N. E.*'s sleeping cars are 66 ft. 6 in. (20.27 m.) long over bodies and 5 feet (1.52 m.) longer than all their former cars, which has increased the capacity from 28 to 32 berths.

(*) This illustration is reproduced from *The Locomotive*.

(1) These cars contained 7 single-berth compartments and 2 double. They were 50' (15.32 m.) long and 9' (2.74 m.) wide over mouldings.

(2) Principal dimensions as follows :

Railway Company.	L. M. S.		L. N. E.	
Length over body	65' 1"	19.84 m.	66' 6"	20.27 m.
Do. overall	68' 8"	20.93 m.	68' 6"	20.17 m.
Width over body	8' 11" 1/4	2.73 m.	9' 0" 3/4	2.75 m.
Bogie wheelbase	9' 0"	2.74 m.	8' 6"	2.59 m.
Do. centres	48' 0"	14.63 m.	47' 0"	14.33 m.
Number of compartments	7	7	8	8
Do. of berths	28	28	32	32

It is a sign of the times that the latest service from Glasgow to Inverness, inaugurated in January 1932, should have third class sleepers only.

The charge for a sleeping berth is paid for the night and not according to distance as on the Continent. It amounts to 15 sh. in first and 6 sh. in third, either in England or in Scotland, and to 20 sh. and 7 sh., for any Anglo-Scottish run.

The number of these services is on the increase; there now are 74 of them (besides 66 return services) as compared with a pre-War both ways total of 68. With the exception of three Glasgow services, they are all run on London trains. We have shown them in figure 9 and underlined the name of each place sleeping cars are run to, using each Company's distinguishing line for the purpose.

These services are now run between the following places :

G. W. — Paddington to Penzance (and Plymouth), and to Fishguard (and Neyland).

L. M. S. — Euston to Inverness (Forres and Perth), Oban, Aberdeen (and Dundee), Edinburgh, Glasgow, Kilmarnock (Turberry and Stranraer).

Also to Liverpool, Manchester and Holyhead.

And from Glasgow to Liverpool, Manchester and Inverness.

L. M. S., former Midland Ry. — Most of these services have been transferred to the West Coast Route. There only remain those from St. Pancras to Edinburgh and to Glasgow.

L. N. E. — King's Cross to Inverness (Forres, Lossiemouth, Aberdeen, Dundee and St. Andrews and Edinburgh ; to Perth, Fort William (and Glasgow), North Berwick (and Newcastle).

Railway Companies' restaurant-cars. — The *Great Northern* provided the earliest of them in 1879, and the *Great Eastern* ran the first third-class diners. It was also the first to include *breakfast cars* in its morning East Coast up trains, which returned in the evening, as dining cars.

Mr. Gresley's system of articulated coaches was first used for East Coast restaurant triplets. There was a kitchen car in the centre, having « open » first and third-class restaurant cars on either side (1) (fig. 18). Kitchen compartments or cars are of large size because they provide meals and refreshments for

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(1) We quote below principal the dimensions of an East Coast tripelt set. The centre coach is a kitchen car, without vestibules. It has on one side a 3rd-class restaurant car, seating 42 passengers in two saloons and, on the other, a first-class restaurant car, seating 36 in two saloons.

Date of construction of the set.		1928	
Length over body headstocks.	153' 7"		46.81 m.
Do. over buffers	155' 7"		47.42 m.
Bogie wheelbase.	8' 6"		2.59 m.
Overall width	9' 0"		2.74 m.
Total weight.	83 t. 7 cwt.		84.6 metric t.

Special dimensions concerning each of the cars :

Type of car	*3rd-cl. R. car.*	*Kitchen.*	*1st-cl. R. car.*
Length over head-stocks.	55' 2" 1/2 16.82 m.	41' 0" 12.50 m.	55' 2" 1/2 16.82 m.
Bogie centres	47' 0" 14.33 m.	42' 1" 12.83 m.	47' 0" 14.33 m.
Weight on bogie . . .	On 1st: 18 t. 1 cwt. (18.3 metric t.)	On 2nd and 3rd: 23 t. 13 cwt. (23.4 metric t.)	On 4th: 17 t. 19 cwt. (18.3 metric t.)

Fig. 18. — Recent *L. N. E.* set of triplet 1st and 3rd-class restaurant cars.

passengers travelling in the ordinary coaches besides those using the restaurant. But these triplets are heavy, which is a drawback; the *G. W.*'s, for instance, weigh 110 tons, and the kitchen car alone, 44. So in 1932, the Company substituted two car sets instead; one of them was a kitchen and first-class restaurant car, the other, a third-class one, without a kitchen. These two cars weighed but 40 + 33 tons for 24 + 64 passengers.

The charges for table d'hôte meals have been standardised :

L. N. E.	3 sh. 6 d. and 2 sh. 6.d.
Southern	Do.
L. M. S.	all 3 sh. 6 d.
Great Western . .	3 sh. 6 d. and 2 sh. 6.d.

save for *G. W.* runs onto other systems (3 sh. 6 d.) and on the « Cornish Express » (4 sh.).

Restaurant car rosters frequently embrace a considerable mileage which causes long daily working hours; the staff then works but 5 and even 4 days a week.

On the *L. M. S.*, the same cars run 520.9 miles (838.4 km.) from Sheffield to Glasgow Central and back in a day, leaving at 7.55 a.m. and returning at 10.13 p. m.

The *L. N. E.* cars run from Newcastle to King's Cross and back, a distance of 537 miles (858.9 km.), between 8 a. m. and 10.50 p. m.

The Summer Leeds, Newcastle and Glasgow service, accomplished between 8.55 a. m. and 10.28 p. m., with but an hour to spare in Glasgow, is even longer, covering 555 miles (893.1 km.).

These lengthy hours and considerable mileage are to be met with on Pullman services as well, the « West Riding Pullman », for instance, running 558 miles (898 km.) each week day.

Buffet cars. — Not only have third-class diners appeared but, as on the Continent, a cheaper form of meals can be had in buffet cars of various kinds and various denominations.

The *G. W.* 1932 café-cars have a seating

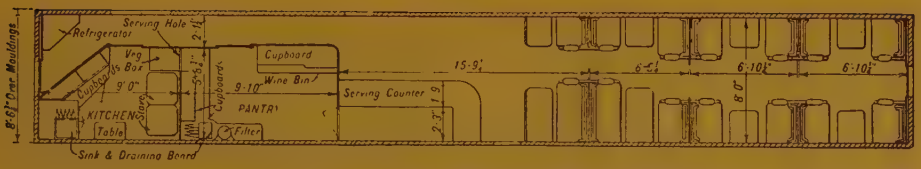

Fig. 19*. — *Great Western* café-car.

capacity of 17 or 19. They are of the usual 60-foot (18.28-m.) length (1).

In the *L. N. E.* London and Cambridge « cafeteria », passengers are served by the staff, whereas they help themselves at the café-car counter. These three-car sets run four times daily to Cambridge and back and these « beer trains », as they have been nicknamed, have already been lengthened to five cars.

The first buffet cars were introduced long ago by the *G. C.*, and have reappeared recently, but whereas on the *L. M. S.* passengers must help themselves (as on the *Canadian National*), there is a staff for the purpose on the *G. W.*

The *L. N. E.* recently introduced buffet-cars on its new King's Cross and Cambridge service and improved cars between Leeds and Newcastle. They have a 37' 4" (11.38 m.) saloon with 22 seats and a 11' 3" (3.43 m.) counter. The entire inner scheme is a new and happy one, the tables and chairs having chromium plated tubular steel tubes and Rexine upholstered backs.

In later cars, there are 24 seats (in a 42' 6" = 12.93 m. saloon), and the kitchen, where light meals can be prepared, is 15' 8" (4.77 m.) long. Other leading dimensions are :

Kind of car.	*Buffet car.* 1932		*Sleeping car.* 1932	
Date of construction				
Length over headstocks.	60' 0"	18.29 m.	65' 0"	19.81 m.
Do. of body	61' 6"	18.74 m.	66' 6"	20.27 m.
Do. overall	63' 6"	19.35 m.	68' 6"	20.88 m.
Bogie centres	43' 0"	13.10 m.	47' 0"	14.33 m.
Do. weelbase	8' 6"	2.59 m.	8' 6"	2.59 m.
Width, inside	7' 11" 3/4	2.43 m.	8' 7"	2.62 m.
Do. over body	8' 11" 3/4	2.74 m.	9' 3"	2.82 m.
Height rail to top of roof	12' 6"	3.81 m.	12' 6"	3.81 m.
Do. overall	12' 10"	3.91 m.	12' 10"	3.91 m.
Weight, English (*metric*) tons	33	33.5	42.12	42.7

33 new cars are being provided for the excursion and tourist trains.

CHAPTER IX.

Trains other than main line expresses.

IX-1. — **Summer traffic and excursion trains.** — The enormous Summer traffic taxes the Companies' resources to the utmost. Increasing the weight of main line expresses up to 500 tons and more is not sufficient to cope with it. Reliefs have to be run and express trains are

(*) Reproduced from *The Locomotive*.

(1) Other dimensions are :

Length over headstocks.	59' 5"	(18.11 m.).
Wheelbase.	48'	(14.63 m.).
Bogie wheelbase	10'	(3.05 m.).
Width outside body	8' 6" 3/4	(2.61 m.).

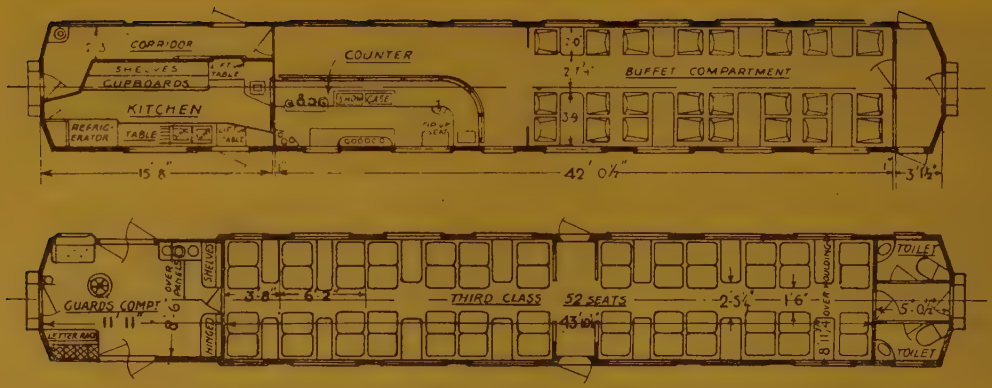

Fig. 20. — Recent *L. N. E.* tourist and excursion cars (*).
a) 33-ton buffet-kitchen car. — *b*) Open third-class saloon and guard's compartment, weighing 32.2 tons.

bunched together at certain times of the day so that it should be possible to duplicate or triplicate them easily.

In the Summer of 1931, for instance, (which we choose intentionally as conditions were still favourable), the eleven main line expresses that left King's Cross on Saturdays (1) carried 4 390 passengers on July 31st and 43 extra parts were run on August 1st. On most Saturdays, the « Flying Scotsman » and the « Scarborough Flier » ran in two or three parts (2).

The Summer of 1932 produced the same conditions. Ten expresses, including five sections of the « Atlantic Coast Express », left Waterloo between 10.30 and 11.30 a.m. (3). About as many (besides reliefs) left Paddington (4), and eleven left Liver-

(*) Reproduced from drawing supplied by the *L. N. E. Ry. Co.*

(1) On July 11th, for instance, the weight of these trains was :
the « Flying Scotsman » (520 tons) at 10.00 a. m.,
the 10.10 Yorkshire express (in two parts weighing 500 and 510 tons),
the « Norseman » (405 tons) ; a 540-ton Scotch express,
two parts of a York train (555 and 500 tons), with a Newcastle 550-ton, and a Lincolnshire (380-ton) relief,
and the 565-ton « Highlandman ».

(2) The « Scarborough Flier » ran in three parts weighing 1 310 tons, and the Immingham Cruise Boat Special in four parts weighing about 500 tons each.

(3) Four of these trains ran to Bournemouth and two to Weymouth and Portsmouth; the four sections of the « Atlantic Coast Express » ran to Ilfracombe, to Padstow, to Plymouth and to Exmouth.

(4) 10.30 a. m. train to Penzance; 10.45, to Gloucester; 10.55 to Newquay; 11.00 a. m., to Torquay; 11.05, to Penzance; 11.10, to Birkenhead; 11.15, to Weston-super-Mare; 11.20, to Oxford.

pool Street between 9.45 and 10.30 a.m.(1). With a single exception, these latter trains all ran along the same main line as far as Colchester [51 3/4 miles (83.3 km.)]. It was the same on the *Great Northern*, where six expresses followed each other in the space of 27 minutes, all the way from King's Cross to Doncaster (156 miles = 251.1 km.) (2). But the morning express rush at Euston is spread out over a longer space of time.

The extent of the 1933 holiday traffic came as a surprise. On the Thursday before Easter, the *L. N. E.*'s Yorkshire 5.45 down express ran in 4 parts, weighing 1 800 tons, the cosmopolitan express in six parts (2 200 tons) and even the night Scottish express, was triplicated in 570-ton portions. Altogether, 52 specials were run (3).

There is a current fallacy on the Continent, where British trains are supposed to be light ones. True, all Companies try not to exceed the 500-ton limit, but even so the weight is quite respectable. So as to keep it down, several sections are run when necessary. Thus the through carriages of the 4 p.m. Cleethorpes, Leeds, Bradford, Scarborough and Newcastle 4 p.m. *L. N. E.* ex-King's Cross express in the Winter become so many separate trains at rush times such as Whitsuntide and the Summer holidays (4).

But in the present depressed state of affairs, the usual weights of trains are lower. Here are a few examples :

TRAIN.	Time of departure.	Usual number of carriages.	Weight.
Kings Cross to Edinburgh	10.00 a.m.	11	348 tons.
Do. Glasgow (Pullman).	11.20 a.m.	9	280 —
Do. Newcastle	5.30 p.m.	14	422 —
Leeds to Glasgow	9.00 a.m.	9	304 —

Excursion traffic. — So as to draw excursionists in spite of road competition, the Railways have added considerably both to the comfort and speed of their excursion trains, and their success has been a deserved one. For years, they had simply done as the previous year. This is no longer the case, and railways the World over have had to think if they wished to go one better than their competitors. To judge by results, they have been quite able to do so, the only pity being that this was not done sooner. Instead of using obsolete stock from

(1) These expresses ran to Cromer, Norwich, Yarmouth, Parkeston Quay, Felixtowe, Clacton-on-Sea and Southend.

(2) The 10 o'clock « Flying Scotsman » was followed by two 500-ton parts of the « Junior Scotsman » and three sections of the Yorkshire express.

(3) It took 68 minutes to cover the 59.3 miles (95.4 km.), from Templecombe to Exeter (Queen Street).

(4) On Easter Monday, the up train arriving at 9.13 p. m. came in 4 portions, the 9.25 p. m. in 5 from Leeds and Bradford, and the up Scotsman, in 3.

Fig. 21. — New *L. N. E.* excusion train. Interior of third-class open car with semi-bucket type seats.

Fig. 22. — Interior of a buffet car of the new *L. N. E. Ry.* trains for tourist traffic. The seats are of plated tubular steel.

the duplicate lists, British railways have found it advisable and remunerative to build specially constructed rolling stock for the purpose and to render it as attractive as possible. This is instanced in the latest five *L. N. E.* 12-car day tourist trains, each of which consists of four double articulated third-class cars, two buffet-kitchen cars and two third-class brakes. They weigh 338 tons and hold 600 passengers (1).

Rendering excursion tickets available on regular trains and even in the Scottish express sleeping cars, has also proved an unqualified success.

As is seen, British excursion traffic methods differ happily from the Continental, both in the matter of comfort and speed. Here are some examples of the latter.

On the *Southern Ry.*, a Bournemouth, Plymouth and Exeter (Queen St.) excursion train accomplished the journey at an overall speed of 52.5 miles (84.5 km.) an hour, and that over a hard line (2). The train that brought the « National Sunday

(1) Each train is 677' (206.3 m.) long, to which the various cars contribute as under :

	Length.	*Weight.*	*Seats.*	*Bogie centres.*
Buffet car	63' 6" 19.35 m.	33 tons.	24	43' 13.11 m.
Two-car set	107' 1" 30.80 m.	51 t. 16 cwt.	56 + 56	2 × 43½ ft. (13.20 m.)
Brake thirds	— —	32 t. 2 cwt.	52	— —

The bogies have an 8' 6" (2.59 m.) wheelbase.

(2) During the 1930 Summer.

League » members back from Exeter to Waterloo, was timed at 53.4 miles (85.9 km.) an hour between Honiton and Salisbury (1).

The *G. W.* Swindon Works' visitors came down in special excursion trains that took 80 minutes to negociate the 77.3 miles (124.4 km.) from London to Swindon. On another occasion (February 1st, 1931), when a steeple chase was run, an extra restaurant car and an ordinary coach were added to the *G. W.*'s crack train, the « Cornish Riviera Express » between London and Taunton, bringing it up to 15 carriages weighing 505 tons.

And *L. N. E.* Leeds excursions costing 1 penny for 3 1/2 miles, run faster than the « Queen of Scots ».

In Scotland, the L. M. S. advertised two specials that were to run from Glasgow to see the « Empress of Britain » go down the Clyde. They appealed to eleven thousand passengers...

Similar crowds are to be found, of course, on race days. Thus when the Doncaster St. Leger was run (Sept. 1931), 52 specials (27 *L. M. S.* and 25 *L. N. E.*) arrived between 8 a.m. and 1.30 p.m., with 34 000 passengers travelling in through trains, from London (ordinary and Pullman trains), Leicester, St. Albans, Birmingham, Stafford, Cambridge, Leamington Spa, Northampton, Buxton, Kirby Stephen, Blackpool, Manchester, Chester, Southport, Newcastle, Saltburn.

It might be added that the Newbury Race specials travel at 57.3 miles (92 km.) an hour, taking 55 minutes for the 52.5 miles (84.2 km.) from London to Newbury.

A further draw for excursion crowds is, of course, the low price at which such excellent service is provided. This year, the *L. M. S.* ran excursion trains from Glasgow to Ayr and back (82 miles = 132 km.) for 1 sh. 6 d. and 2 700 passengers responded, and the *L. N. E.* did as well with its 5 000 passengers for the shilling, Edinburgh-North Berwick excursion (45 miles = 68 km.), and for the 1 sh. 3 d. to Stirling and back (80 miles = 129 km.), the 1 sh. 9 d. to Callander (105 miles = 169 km.), and so on.

TABLE 64.

A FEW EXAMPLES OF SEMI-FAST SUBURBAN TRAINS.

(1932-1933 Winter.)

RAILWAY COMPANY	Train running between	Distance		Time of departure.	Time spent.	Speed.	
		Miles.	Km.			Miles/h.	Km./h.
G. W.	Paddington-Slough	18.5	29.8	Many	0.23	48.2	77.5
	Do. -Reading	36.0	57.9	Do.	0.40	54.0	86.9
S. Ry	London Bridge-Horley	25.5	41.0	8.00 p. m.	0.34	45 4	73.0
	Do. -Sevenoaks.	27.2	43.8	R 10.43 a. m.	0.27	45.0	72.4
	Do. -Tonbridge.	26.6	44 5	Many	0.39	42.6	68.6
	Do. -Gravesend.	22.5	36.3	Do.	0.34	28.9	46 5
L. M. S.	Euston-Hemel Hempsted	24.5	39.4	4.55 p. m.	0.32	46.0	74.0
	St. Pancras-St. Albans	20.0	32 2	5.20 p. m.	0.25	48.0	77.2
	Broad St.-Bushey	20.5	33.0	5.24 p. m.	0.32	38 4	61.7

(1) This was a 12-coach train. The distance between Honiton and Salisbury is 71.2 miles (114.6 km.).

IX-2. — **Suburban traffic.** — Besides all stoppping trains, a number of semi-fasts stop for the first time some distance away, thus enabling passengers to reside further and come quickly to town for business or pleasure. Without being really fast, the speed of these trains is quite decent, especially if one considers the crowded lines over which the trains run.

Suburban traffic is very heavy around most English towns. In 1931, on each working day, 1 220 trains entered and left Waterloo, and 1 200, Liverpool Street. At certain times of the day, they followed each other at two-minute intervals the densest traffic occurring on the Chingford and Enfield Green line.

TABLE 65.

A FEW ORDINARY SUBURBAN TRAINS.

(1932/1933 Winter.)

RAILWAY COMPANY.	Train running between	Distance Miles.	Distance Km.		Time of departure.	Time spent.	Speed. Miles/h.	Speed. Km./h.	Intermediate stops.
L. N. E.	King's Cross-Potters Bar.	13.0	20.9		4.15 p. m.	0.25	30.8	49.6	1
	Do. -Hadley Wood	10.4	16.7	R	8.27 a. m.	0.19	33.4	53.7	1
	Do. -New Barnet	9.0	14.5		9.17 a. m.	0.18	30.5	49.1	1
	Marylebone -High Wycombe. . . .	27.6	44.5	R	8.18 a. m.	0.42	39.6	63.8	3
L. M. S.	Electric services.								
	Manchester Vict.-Bury	9.8	15.8			0.24	24.4	39.2	6
	Liverpool Exch.-Southport	18.5	29.8			0.45	24.6	39.6	14
	Euston -Watford Jn. . . .	17.8	28.7			0.42	25.3	40.7	15
	Fastest run (Electric services).								
	Liverpool Exch.-Southport	18.5	29.8		4.32 p. m.	0.28	39.7	63.9	—
	Do. -Waterloo	5.3	8.5		1.02 p. m. S	0.09	35.2	56.7	—
	Wigan-Southport.	16.4	26.3				49.2	79.2	—

Metropolitan services. — The speed of Metropolitan trains varies within wide limits on urban sections or suburban extensions where stations are spaced further apart.

The densest traffic occurs between Sloane Sq. and Mansion House, on the *District Ry.*'s southern section, where there are as many as 43 trains in an hour, over the same set of metals.

There are 40 trains at 1 1/2-minute intervals on the Piccadilly line, which is a typical one. Metropolitan stations are nearer East (1), and further apart West of Hammersmith (2). The seven-car trains weigh 168 tons, empty.

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(1) Distances on this section, where the *Piccadilly Tube* duplicates the *District Ry.'s* line :

Hammersmith-Acton Town . 2.8 miles (4.5 km.)
Acton Town-Northfields . . 1.8 — (2 9 km.)
Northfield-Hounslow West . 4.0 — (6.4 km.)

(2) Distance in the opposite direction :

Hammersmith-Wood Green. 11.6 miles (18.7 km.)
Wood Green-Cockfosters. . 5.0 — (8.0 km.)

TABLE 66.

A FEW TYPICAL METROPOLITAN TRAINS.

SECTION.	Kind of train. Run made.	Distance		Average distance between stations.		Time of departure.	Time spent.	Stops.	Speed	
		Miles.	Km.	Miles.	Km.				Miles/h.	Km.
	ALL STOPS.									
Urban	Cockfosters-Hammersmith . .	16.6	26.7	0.64	1.03	6.42 a. m.	0.47	25	21.2	34.
Suburban	Wood Green-Hammersmith . .	11.6	18.7	0.55	0.89	6.48 a. m.	0.35	20	19 9	32.
	SKIPS 3 STATIONS.									
Urban	Wood Green-Hammersmith . .	11.6	18.7	0.64	1.03	8.33 a. m.	0.33	17	20.8	33.
Suburban	Cockfosters-Hammersmith . .	16 6	26.7	0.55	0.89	8.30 a. m.	0.45	22	22.1	35.
	EXPRESS									
	Hammersmith-Hounslow W. .	8.5	13.7	1.41	2.28	8.46 a. m.	0.18	5	28.2	45.
	COMPARISON.									
P. & B. Ry.	Hammersmith-Northfields . .	4.5	7.2	2.24	3.61	8.46 a. m.	0.08	1	31.6	50.
District Ry.	Do. Do.	4.5	7.2	0.64	1.03	8.05 a. m.	0.13	6	20.7	33.

The speed between stations is :

30 miles (48 km.). — Maximum for all-stations trains, on the Metropolitan section.

35 to 40 miles (56 to 64 km.). — Do. on the extensions.

25 miles (40 km.). — Average between all stations.

45 miles (72 km.). — Maximum for trains that skip stations.

IX-3. — **Rail motor cars.** — The only fast British rail motor car service was the « Armstrong-Shell Express » which ran from Euston to the British Industries Fair at Bromwich, from February 20th to March 3rd, 1933.

This 250-H.P. petrol-electric car's [1] schedule was inserted between those of two of the *L. M. S.* 's fast expresses. It left Euston at 11.35 a. m., arriving in Bromwich at 2.03 p. m. [2], with a 6-minute stop at Birmingham [3]. On every journey, it burnt at most 22.5 Imp. gallons of fuel at 3 1/2 d. a gallon, or 6 sh. 7 d. worth altogether [4].

Road-rail cars have been used by the *L. M. S.* since April 1932. They ran by road from a Stratford-on-Avon hotel to the station, and by rail, between the Stratford-on-Avon and Blisworth stations.

Though so few of these cars are in service, there are quite a number of autotrains which run at the same speed as other trains.

(1) The commercial railbus weighs only 17 1/2 tons with a capacity of 57 passengers and a guard's compartment, or 71 passengers and no such compartment, and an Armstrong-Saurer 95-H.P. engine.

It weighs 18 tons 17 cwt., with a 140-H.P. engine instead. This corresponds to a weight of 6 tons per axle or 0.31 and 0.25 per passenger.

Principal dimensions :

Length of body. . . .	52' 6"	(16.0 m.)
Width.	8' 11 1/2"	(2.73 m.)
Height, rail to roof. .	11' 11 1/4"	(3.95 m.)
Bogie centres	30'	(9.14 m.)
Do. wheelbase	7'	(2.13 m.)
Wheel diameter . . .	2' 9"	(0.84 m.)

(2) On the up journey, it left Bromwich at 4.43 and arrived at Euston at 7.15 p. m.

(3) From 1.41 to 1.47 p. m.

(4) On February 24th, the railbus consumed 20 gallons (91 litres) only, costing 5 sh. 10 d.

IX-4. — **Goods trains.** — There are two reasons why it has been advisable to accelerate goods traffic. Trains are got out of the way as quickly as possible and consignors are incited to use rail instead or road transport. Practically any consignment is delivered the next morning, however distant the destination, and this means a great deal of night work.

As with fast passenger trains, goods expresses are bunched together and some of them run considerable distances. The longest journeys are those run by perishable traffic trains from Aberdeen to London, by the East and West Coast Routes. The latter has two long non-stop runs from Carlisle to Crewe and from Crewe to Euston.

But there is a longer service still, entirely on the *L. M. S.*, over the 850 miles (1 368 km.) which separate Thurso from Bournemouth.

There are noteworthy goods trains by the three Glasgow and Edinburgh routes to London, including the East Coast's « Scotch Goods » (see p. 916/32, Part I.). The *L. M. S.* Glasgow and St. Pancras train stops at Carstairs to pick up a Perth connection, then at Carlisle and Crewe only. These non-stop runs, though very extensive, are shorter than the same Company's London and Edge Hill (Liverpool) 191-mile (307 km.) non-stop run. High speeds up to 55 miles (88.5 km.) an hour are maintained by these trains on favourable sections.

This has been rendered possible by the application of the continuous air brake, and goods trains are classed according to the proportion of braked wagons, and to a lesser degree, according to the kind of axle boxes (oil, grease), draftgear, etc.

The *L. M. S.*'s first class goods trains, contain one half, and their second class trains, one third of braked wagons. *Moguls* take 45 or 50 of them and a van.

Ordinary express goods trains have 4 braked wagons only; then come, going downwards, ordinary loose goods expresses, through goods trains, mineral trains and ordinary stopping or pick-up goods trains.

The *G. W.* has some 60 C class trains, one third of their 64 to 67 *Mogul* hauled or 70 *Consolidation* hauled wagons being braked. A maximum speed of 45 miles (72 km.) an hour is authorised.

Accelerated class E trains have but 4 to 9 braked wagons, this number depending on the total number of vehicles, the other wagons having oil or grease axle boxes. Maximum speed, 35 miles (56.3 km.) an hour.

E and F trains, which have no braked wagons, are not allowed to travel at over 30 miles (48 km.) an hour.

But train running is not the only factor that has expedited goods traffic. The provision or rather improvement of large marshalling yards such as that of Little Mill, near Pontypool Rd., have shortened the journeys from Manchester to Cardiff, and from Birmingham to South Wales by a couple of hours — which is quite appreciable.

The *L. N. E.* has a somewhat similar classification and runs 119 fully braked and partly braked trains.

Its perishable expresses travel by priority, even ahead of passenger expresses. Scotch meat trains, Derbyshire and North Staffordshire milk trains, all run non-stop from Grantham to King's Cross.

Vegetable traffic has been built up and developed in the same way. *L. M. S.* trains are run 225 miles (362 km.) from Birmingham to Carlisle with a single locomotive and at a sufficiently high rate of travel, for them to reach Glasgow early the next morning.

Formerly, but a few wagons of peas

went from Leeds to St. Pancras. Since freight accelerations, they have grown into three whole trains every day. As much could be said of the Avonmouth and Garston banana traffic, these ports now daily sending a score of special temperature trains to all parts of the system.

The *L. N. E.* 's Peterboro' and London coal expresses run at different speeds in the up or down direction. They are made up of 56 twenty-ton wagons, a brake van and a braked brick wagon.

On the *L. M. S.*, there are daily seventeen 1 400-ton coal trains from Nottingham and Derby, covering in 6 h. 40 m. the 127 miles (204.4 km.) from Tooting to Willinborough, their average speed being 19 miles (30.9 km.) an hour.

It is for this traffic, with trains made up of 87 wagons each, that 33 Garratt locomotives have been provided.

We have grouped, in Table 67, a number of interesting data concerning goods traffic, stating only such items as it may be useful to possess.

TABLE 67.

INTERESTING GOODS TRAIN RUNS.

COMPANY. Runs made.	Distance		Time of departure.	Time spent.	Speed		Remarks.
	Miles	Km.			Miles/h.	Km./h.	
L. M. and S. Ry.							
Aberdeen-London Broad St. . .	545.0	877.0	9.45 a. m.	13.40	40.0	64.4	Meat.
Carlisle Crewe	141.0	226.9	8.20 p. m.	. . . .			
Crewe-Broad St. (3.20)	162.9	262.2			41.5	66.8	
Camden-Liverpool Edge Hill . .	191.0	307 4	7.45 p. m.	4.54	39.0	62.8	
St. Pancras-Glasgow Buch St. .	418.8	674.2	R 6.50 p. m.	11.25			
Camden-Crewe (South Sidings) .	156.0	251.1					
Glasgow College-Sheffield . . .			6.25 p. m.				
Birmingham-Carlisle	225.0	362.0	4.30 p. m.	7.58			
L. and N. E. Ry.							
King's Cross-Aberdeen.	526.0	846.8			R 44 0	70.8	Meat, fish.
Id. -Glasgow High St. .	436.0	702.0	3.40 p. m.	13.38	R 39.6	63.8	
Clarence Yard (Ln.)-Edinburgh .	389.0	625.			41.2	66.3	
Marylebone-Glasgow	470.0	756.4			R 37.7	51.6	
Newcastle-Liverpool	196.0	315.8			39.9	64.2	
Spitafields (London)-Harwich.	68.0	109 4			27.6	44.5	
King's Cross-Manchester	210 0	338.0			32.3	51 9	
Id. -Leeds	186.0	300.0			35.5	57.1	
Finsbury Park-Grantham. . . .	103.4	166.4	9.02 p. m.		R 45.0	72.4	
Id. id.	102.9	165.5	10 22 p. m.		R 47.9	77.0	
Id. -Netherfield . . .					R 40.6	65.4	
Ferme Park (London)-New England (Peterb.).				4.00	R 18.5	27.8	
Id. id. . .					24.5	39.4	
Doncaster- id. . .				3.48	20.5	33.0	
Great Western Ry.							
Old Oak Common-Penzance-Newbury Racecourse-Newton Abb.	141.5	227.7	9.32 p. m.	...	40.0	64.4	
Paddington - Birkenhead - Cotton Hill-Shrewsbury	145.5	234.2			38.6	62.2	
Paddington-Newton Abbot-Acton-Westbury-Taunton	152.5	245.4			33.5	53.9	

CHAPTER IX*bis*.

VI-1. — **Boat trains** (Pages 1035/53). — We append a table of distances between London and Dover (Marine), by the *Southern Ry.*'s eight alternative routes, each of which is used by through expresses, either continuously or occasionally.

TABLE 68.

DISTANCES FROM LONDON TO DOVER (MARINE) BY VARIOUS ROUTES.

Line followed.	From Charing Cross.	From Cannon street.	From Victoria.	From Holborn.	From London Bridge.
	(*) m. ch.	m. ch.	m. ch.	m. ch.	m. ch.
Via Hither Green, Orpington, Tonbridge, Ashford	76. 72.	75. 59.	...	..	75. 3.
Via Herne Hill, Orpington, Tonbridge, Ashford	...	...	77. 78.	78. 39.	...
Via Catford Loop, Orpington, Tonbridge, Ashford	...	...	79. 8.	...	...
Via Herne Hill, Swanley, Maidstone East	...	...	80. 3.	80. 44.	...
Via Catford Loop, Swanley, Maidstone East	...	...	81. 13.	...	...
Via Herne Hill, Swanley, Chatham, Faversham	...	...	78. 30.	...	...
Via Catford Loop, Swanley, Chatham, Faversham	...	...	79. 40.	...	...
Via Hither Green, Swanley, Chatham, Faversham	77. 23.	76. 10.	...	...	75. 3.4

(*) m. = miles. — ch. = chains.

VI-3. — **Alternative routes** (p. 1047/65). — In the 1st part of this paper, we alluded to by-pass lines built so as to avoid passing through certain badly situated or congested stations and yards. Figure 23 shows two such instances on the *G. W.*'s main line.

Fig. 23. — Frome and Westbury by-pass lines, *Great Western. Ry.*

VI-6*b*. — **Trans-London expressses** (p. 1058/76). — Owing to the congestion of the London railway area, when travelling from one of the Railway Systems to another, these trains are diverted over other lines such as the Reading-Redhill line joining the *G. W.* and *Southern* Railways. Certain excursion trains accasionally cross the London area, but the only regular train to do so is the « Sunny South Express », the route of which is shown by figure 24.

Fig. 24. — Map of London showing the route of the « Sunny South Express » from the *L. M. S. R.* to the *Southern Ry.* System.

The question of cross-capital railway services is as important as that of cross-country services, but as the « Sunny South » seems to be the only instance as far as London is concerned, it would be out of place to discuss the question at any length here and we shall do so when dealing with the Paris, Brussels, Berlin and Vienna through train services.

(To be continued.)

[625. 143.4 (.945) & 665. 882 (.945)]

Long welded rails.

(The Railway Gazette.)

For more than a quarter of a century the rail length generally favoured in Europe, including the British Isles, was from 45 to 60 feet. In North America 33-foot rails for long reigned supreme. Since the war there has been a progressive tendency to use longer rails. America has adopted 66-foot rails on a large scale; Great Britain has standardised the 60-foot length and is experimenting with 90-foot rails. On the Continent 24-metre (78-ft. 9-in.) rails are becoming common, and the former German standard of 15 metres (49 ft. 2 in.) is now largely replaced by 30-metre lengths. Germany has accomplished this extensive replacement by rolling 30-metre rails, as well as by end-to-end welding of 15-metre rails in the track. Experiments have been carried out with welding even greater lengths, and it is now common to find all joints eliminated on bridges and in tunnels. At the ends of the former, special expansion joints have been arranged, but in tunnels temperature changes are small and no special expansion arrangements are necessary. It has been found that, where several 30-metre lengths have been welded together experimentally in the open, nothing like the full theoretical expansion occurs, and, provided the track is sound and adequately ballasted, no trouble is experienced, the frictional resistance between the the ballast and sleepers being great enough to overcome the tendency to loss of alignment due to the inherent stress set up in the rails which cannot expand under rise of temperature. This has been the experience of the Victorian Railways, on which lengths up to 220 feet have been welded together, as described in the article hereafter.

Editorial *(The Railway Gazette).*

Long welded rails on the Victorian Railways.

In the past the length of railway rails used on the Victorian Railways has been determined by transport considerations and has varied from 22 ft. 6 in. to 45 feet, which is the present standard length. Recent progress in the art of welding has, however, made possible the use of very long rails and by arrangement with the Thermit International interests in Australasia, experiments were commenced in October, 1931, of rails welded into lengths up to 225 feet. Owing to the satisfactory results obtained, and in view of experience abroad, the Thermit process has now been adopted in relaying 100- and 110-lb. rails on the Melbourne suburban electrified lines.

To date about ten track-miles of long rails have been laid, the lengths being as follows :

On the straight and curves over 60 chains radius	225	feet
On curves over 40 to 60 chains radius	180	—
On curves over 30 to 40 chains radius	135	—
On curves over 20 to 30 chains radius	112.5	—
On curves over 15 to 20 chains radius	90	—

The tracks are ballasted with broken stone, 1 1/2-inch gauge, boxed level with

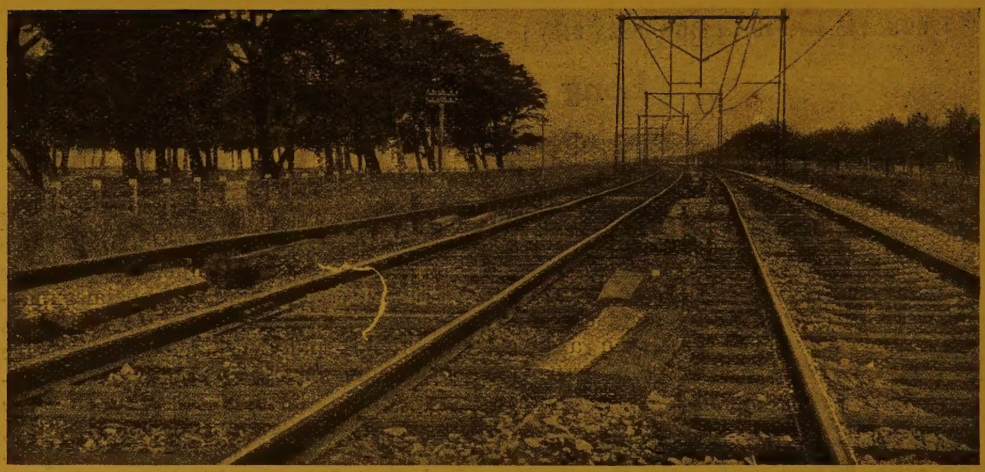

Fig. 1. — Left : Old 100-lb. rails in track before welding. — Right : Old 100-lb. rails re-used and welded into lengths of about 225 feet.

the top and shouldered 16 inches beyond the ends of the sleepers, which are 9 feet long × 10 inches × 5 inches, spaced 2-ft. 3-in. centres, except at the rail joints, and fastened with 3/4-inch dogspikes. Rail anchors are applied as found necessary to stop creep of the rails, usually at half the number of sleepers in each rail length where traffic is in one direction.

The rail joints are Australian standard with four 1-inch fishbolts, and a separate bridge plate spanning the joint sleepers which are spaced 1 ft. 8 in. centre to centre. The gap allowed for expansion and contraction of the rails in the joints as designed is 11/16 inch, which, although only one half of the theoretical variation in the length of a 225-foot rail under a rail temperature range of 100° F., has been found sufficient. The cost of a Thermit joint in 100 or 110-lb. rail is 36sh., or about 4sh. less than the cost of the standard four-bolt bridge joint bonded for electric traction.

In carrying out the work it has been found that by sawing off the battered ends of old rails, which are otherwise serviceable, and welding them together, a track almost as good as new can be obtained. By this means considerable economies in renewals are effected, approximately four-fifths of the mileages welded to date consisting of old rail, most of which had been in service over thirty years.

The Melbourne suburban system comprises 325 miles of main track and carries a heavy suburban electric and country steam service. Maximum axle loads are 15 tons for electric cars, 18 1/2 tons for wagons, and 23 1/2 tons for locomotives.

The chief advantages of long welded rails are :

1. Saving in maintenance costs due to fewer joints and re-use of old rails;
2. Saving in maintenance of rolling-stock, especially the machinery and electrical equipment;
3. Better conductivity and reduction in current used;
4. More comfortable travelling.

Although the Thermit process is well known, it may be of interest briefly to describe its principles here.

The Thermit process of welding is based on the property of aluminium to

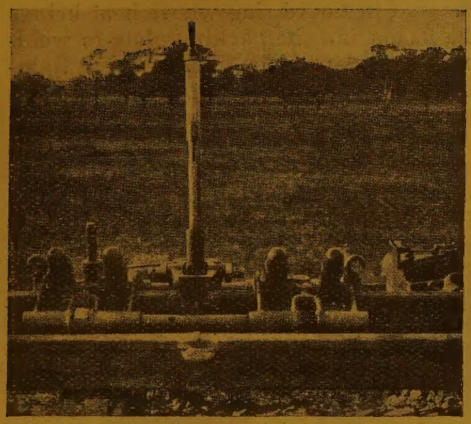

Fig. 2. — Thermit weld completed.

combine rapidly with the oxygen in metal oxides, forming alumina and liberating the metal. This reaction takes place at a very high temperature, exceeding 3 000° C., requires a temperature of at least 1 000° to start it, but once started continues rapidly until complete combination of the aluminium with the oxygen available in oxides. For welding purposes iron oxides are used, and the resulting metal of the reaction is a highly-superheated liquid iron, or steel, which is used to form the weld required.

One of the chief uses of the process is for the welding, in the field, of railway and tramway rails. The operation is a relatively simple one, requiring only a cheap and portable equipment. The rails, having been aligned in the track, or alongside the track on a few temporary sleepers, with a gap of about 3/8 inch between adjoining rail ends, the joint is encased in a special pre-cast sand mould so designed that the liquid metal, which will be poured into it, shall fill the gap and also fill a narrow collar running round the periphery of the gap.

By means of a special lamp, burning petrol or paraffin, the rail ends within the mould are, in from 15 to 25 minutes, brought to a suitable red heat; at this moment the Thermit mixture, which has been placed in a small crucible suspended over the mould, is ignited, and some 10 seconds later its contents are tapped into the mould. A process of decanting has taken place in the crucible, owing to the greatly differing specific weights of the metal and of the alumina slag, so that when tapped the metal flows first and fills the mould before the slag issues from

Fig. 3. — Thermit welding equipment.

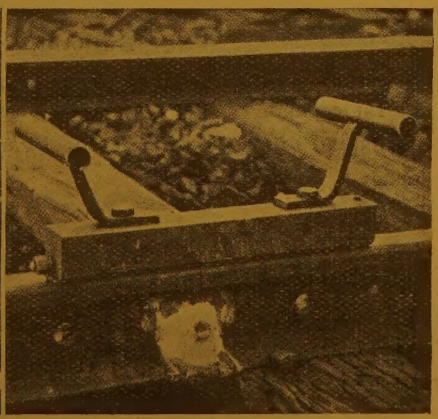

Fig. 4. — Rail file for finishing.

the crucible. After a few minutes the mould is stripped and the welded rail joint is trimmed, whilst the metal around it is still hot and easily cut. Filing of the running surface completes the operation.

This is known as the fusion process, used when the carbon content of the rails is high, when the rails are already fixed in the road bed, and also for welding old worn rails. There is also the butt welding process, used exclusively with rails that are free to move longitudinally. In this process the weld metal is only brought up to the level of the under side of the rail. Above this level the faces of the rail are carefully planed parallel, with a special tool, and a packing plate of special iron is inserted between the faces. The ends of the rails are gripped in a clamp that will serve to draw the ends together with considerable pressure.

The mould is so dimensioned that the heads of the rails, after pouring, will be encased in liquid slag whose heat brings the heads and the packing plate to welding temperature; the clamps being tightened, the packing plate becomes welded with the rail on each side.

Both processes are extensively used on railways on the Continent. To the end of 1930 some 1 700 km. of track on the German State Railways had been welded in lengths of from 30 to 60 m.; since then the welded lengths have tended to increase and now 120-m. lengths are being welded experimentally.

In France, the Nord and other railways have taken up welding, both for main and branch lines; the process has been found economical in utilising hammered rails which would otherwise have had to be discarded. Switzerland, Italy, and Hungary are also using the process on their State railways.

The accompanying photographs illustrate the work carried out with both new and re-used rails on the Victorian Railways.

ERRATUM.

Bulletin, October 1933 number.

Article : *Electric lamps for railway signals*, by E. W. Beggs, page 958, 1st line of 1st column.

Instead of : « and is of the *lightest* order », read : « and is of the *highest* order ».